SPLIT SAMPLING EVENT DATA REVIEW AND DISCUSSION

Data collected at the Homestake Mining Company Grants site by USGS and HMC/Arcadis in 2016

February 15, 2018

90041456

Meeting Agenda

- Introductions
- Site Orientation
- Split Sampling
  - Big picture conclusions
  - HMC-USGS data comparisons
  - Data by sampling method
- Passive Samplers
- Geophysics
- New DD wells
- Drilling, soil sampling, and geophysics at DD and DD-2
- Action Items

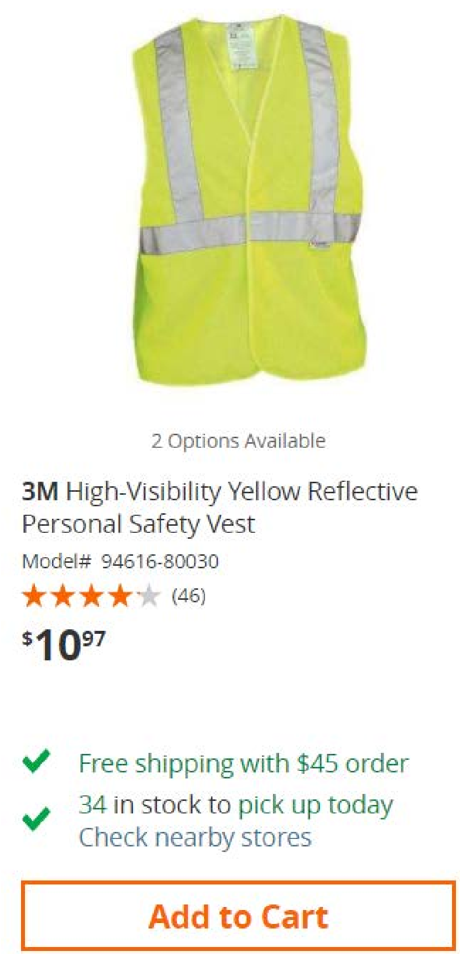
Design & Consultancy for natural and built assets

Health and Safety Moment

Safety vest for personal vehicular use

- Being struck by a vehicle is the sixth leading cause of occupation-related death for California Highway Patrol officers

- Keep a vest in your vehicle, preferably within reach without having to exit vehicle
  - In glove compartment
  - Under front seat
  - In pocket behind seat

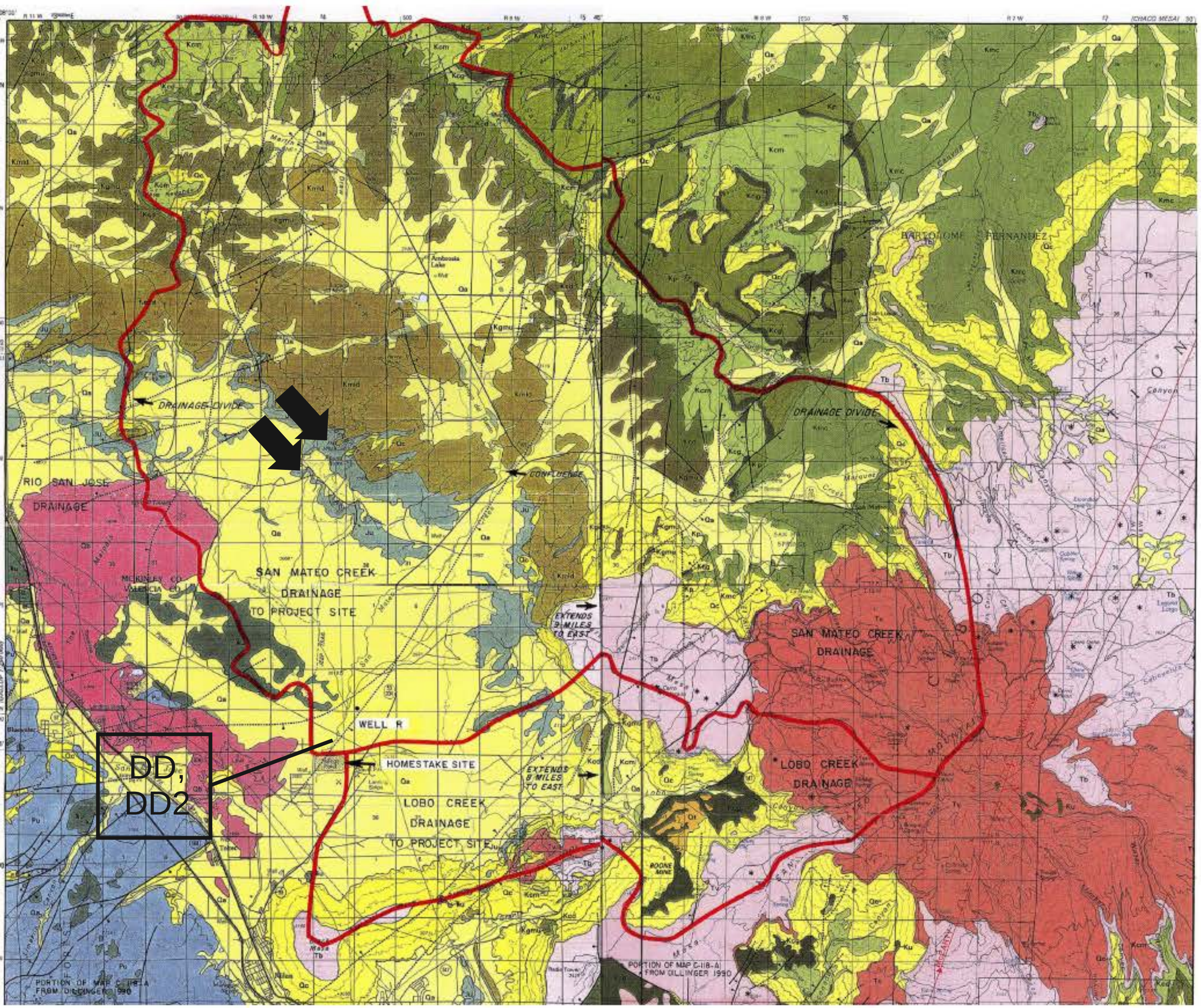


The site

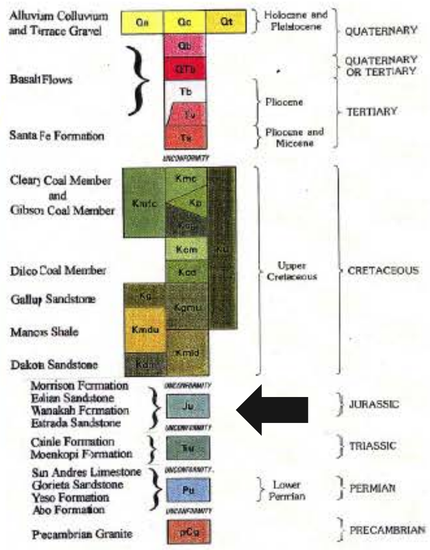
San Mateo Creek Basin

San Mateo Creek Basin Geology

ARCADIS Design & Consultancy for natural and built assets



LEGENDS: Correlation of Map Units



Source:
Dillinger, J.K., 1990, Geologic map of the Grants 30' x 60' quadrangle, west-central New Mexico: U.S. Geological Survey, Coal Investigation Map C-118-A, scale 1:100,000.

GRANTS RECLAMATION PROJECT
Updated Corrective Action Program (CAP)

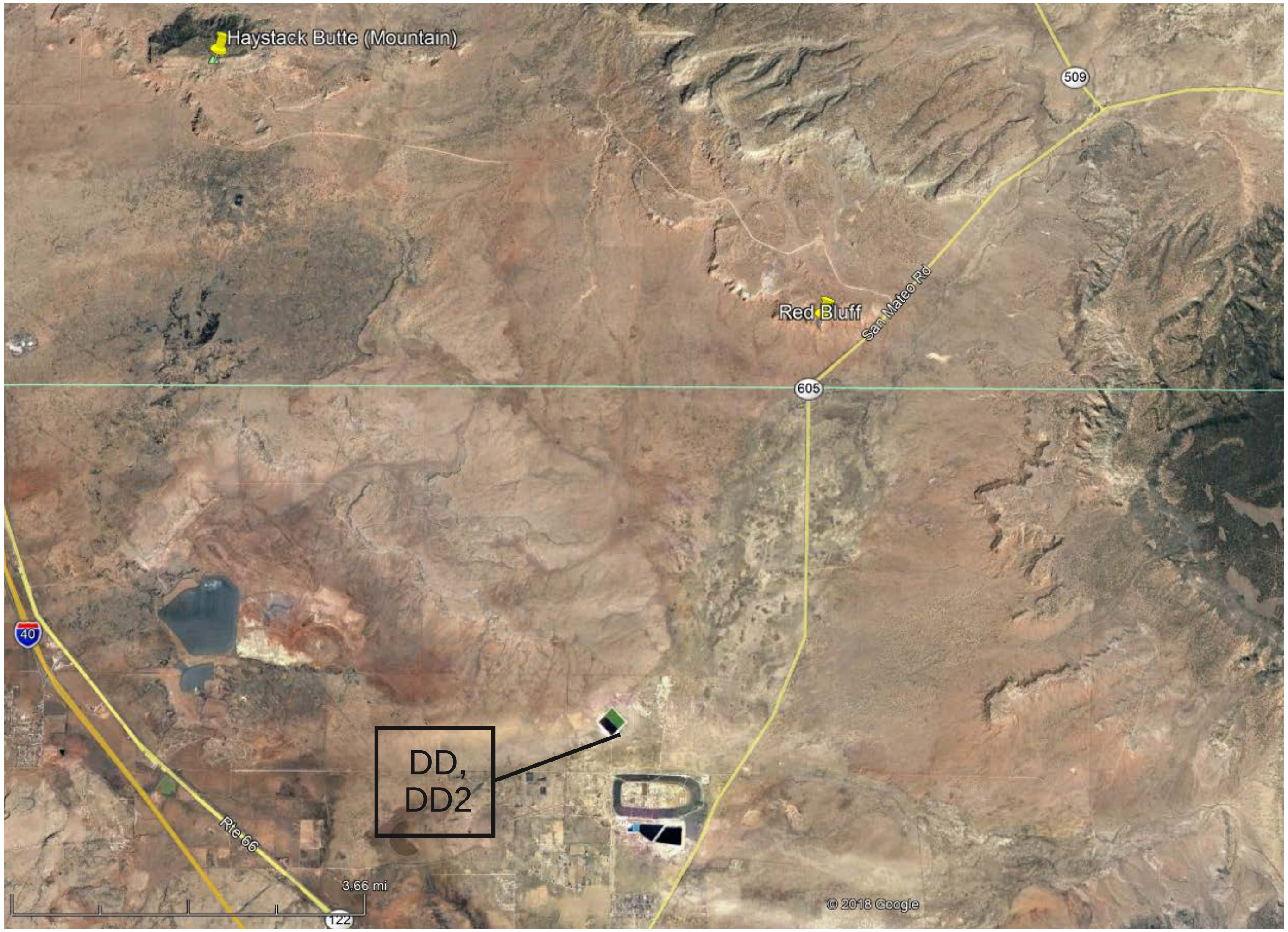
FIGURE 3.1-1
BEDROCK GEOLOGY

Alluvium comes from eroded highlands

This rock contains ore-grade uranium

Results in disseminated uranium particles in alluvium

Erosion/fluvial deposition is a heterogeneous process (visible)



Split sampling event: Summer 2016

What was collected

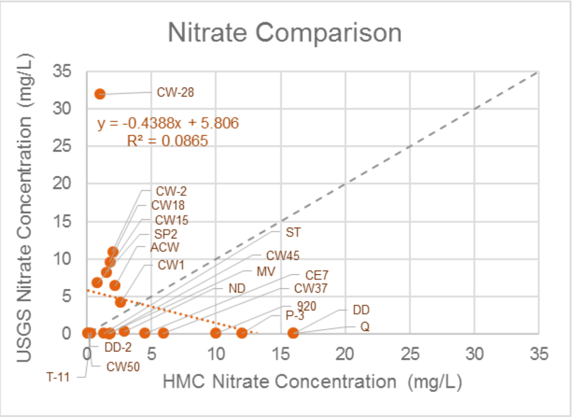
- Field parameters
- 3 types of water samples: volumetric, micropurge, passive sampler
- Metals
- Major anions and cations
- Nitrogen compounds
- Alkalinity
- Total organic carbon
- Radionuclides
- Isotopes
- Dissolved gases (CFCs)
- Geophysical data
- Field Hach analyses: dissolved oxygen and ferrous iron

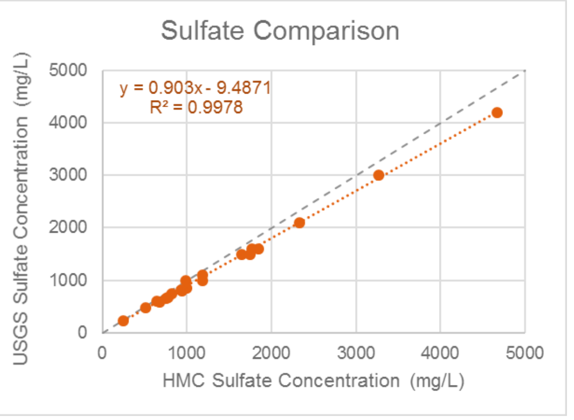
What we have received

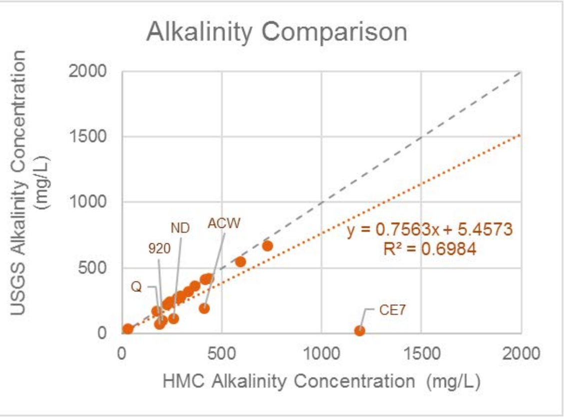
- ✓ Field parameters
- ❑ 3 types of water samples: volumetric, micropurge, passive sampler
- ✓ Metals
- ✓ Major anions and cations
- ✓ Nitrogen compounds
- ✓ Alkalinity
- ✓ Total organic carbon
- ❑ Radionuclides
- ✓ Isotopes
- ✓ Dissolved gases (CFCs)
- ✓ Geophysical data
- ✓ Field Hach analyses: dissolved oxygen and ferrous iron

Split Sampling data – comparing the splits

HMC-USGS Data Comparison

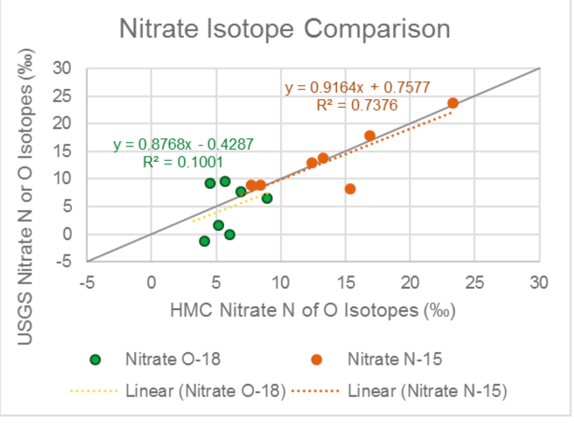


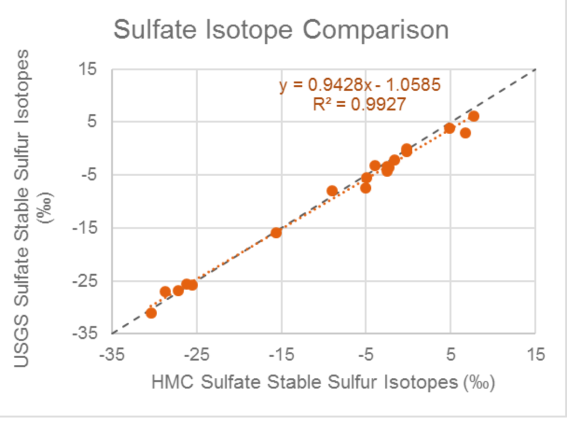




Reasonable data comparability most samples

Five USGS samples with substantially lower alkalinity concentrations

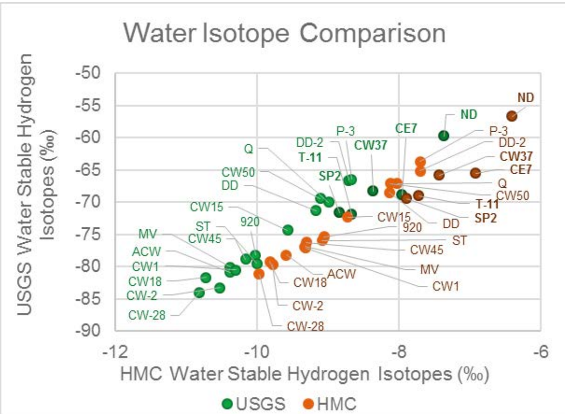


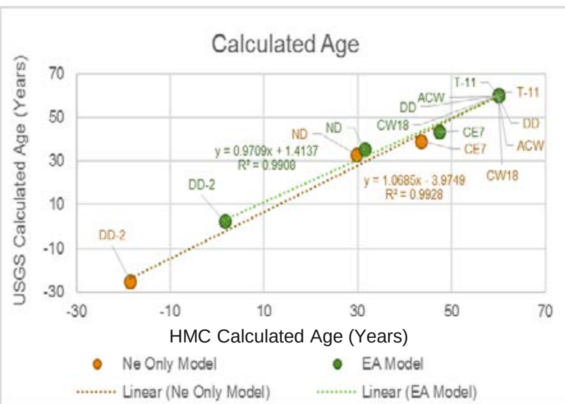


Conclusions similar for both data sets – nitrate primarily from sewage / manure with nitrate reduction occurring

Reasonable data comparability

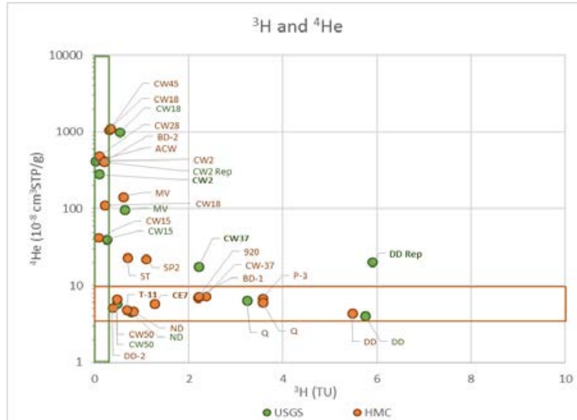
HMC-USGS Data Comparison





HMC data heavier than USGS

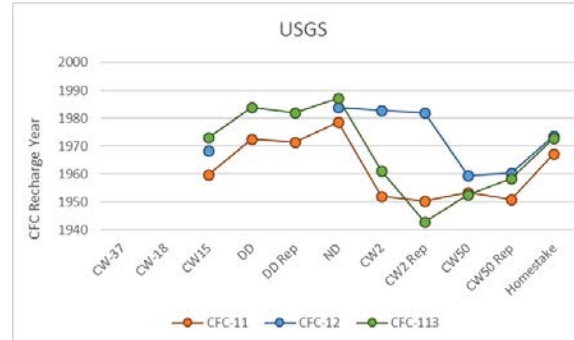
Although HMC data heavier than USGS, interpretations consistent across the two data sets – SP2, T-11, CW37, and CE7 are more evaporated than other samples

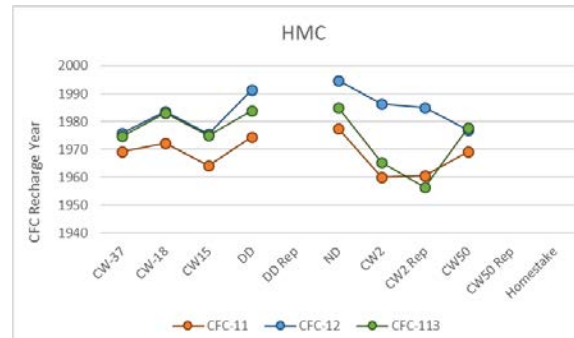


Samples in orange box primarily young water (post 1950)

Samples in green box primarily old water (prior to 1950) – water "age" increases with increasing ^{4}He concentration

Samples outside of boxes are likely mixtures of young and old water, except USGS DD-Rep and CW37 sample results which were qualified as poor fit





HMC recharge year younger than USGS recharge year for CW-15, CW-2, and CW-50

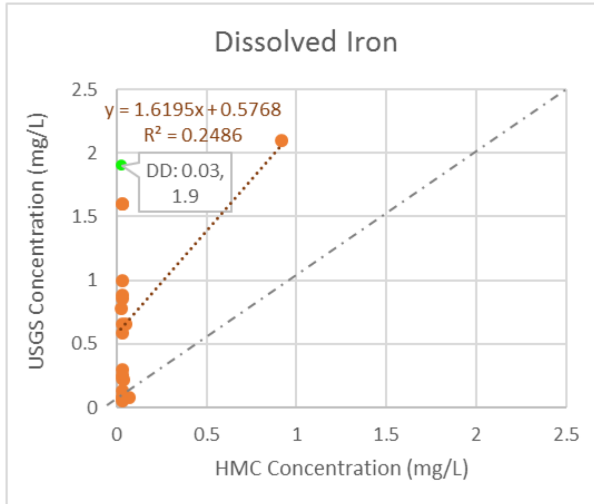
Poor correlation between recharge year for the different CFCs for both USGS and HMC data sets

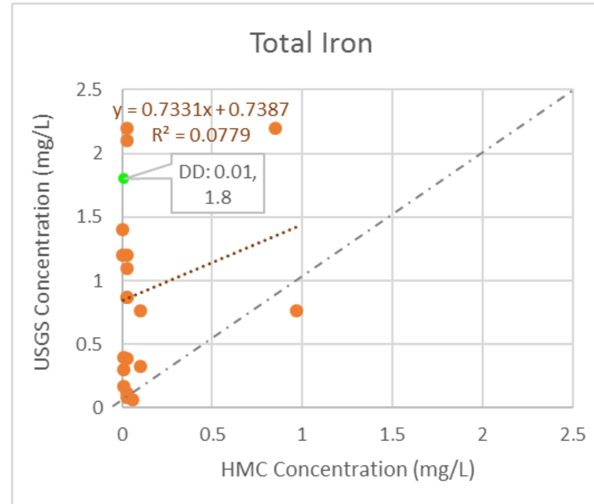
HMC-USGS Data Comparison

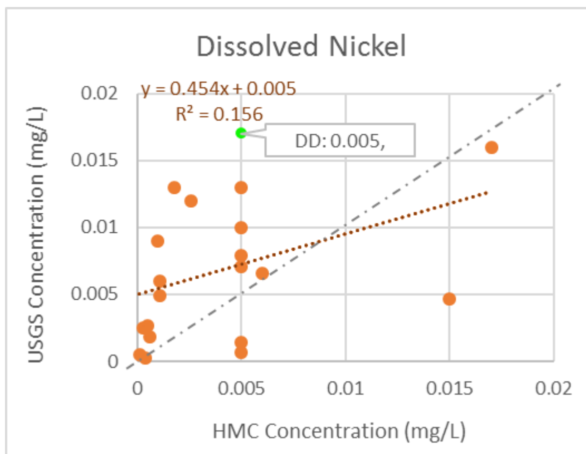
Poor correlation (R<0.25):

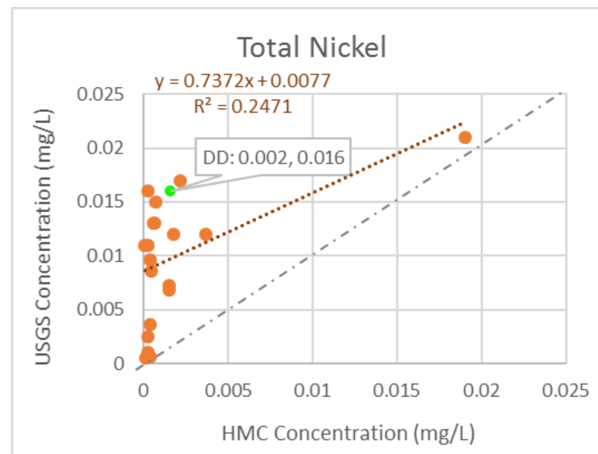
Ammonia nitrogen
Antimony D,T
Cadmium D
Cobalt D,T
Chromium D,T
Iron D,T
Lead D,T
Nickel D,T
Zinc D

Specific conductivity, Ra-228 (T), and potassium (T) show moderate-high correlation after removal of one outlier





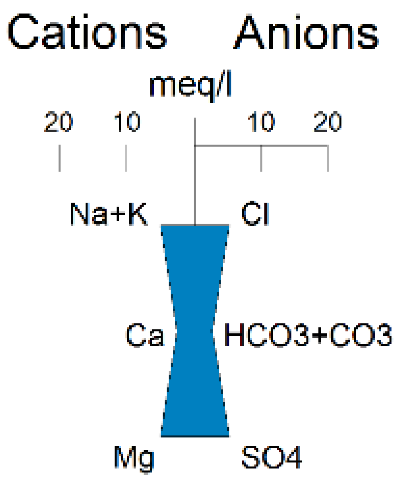




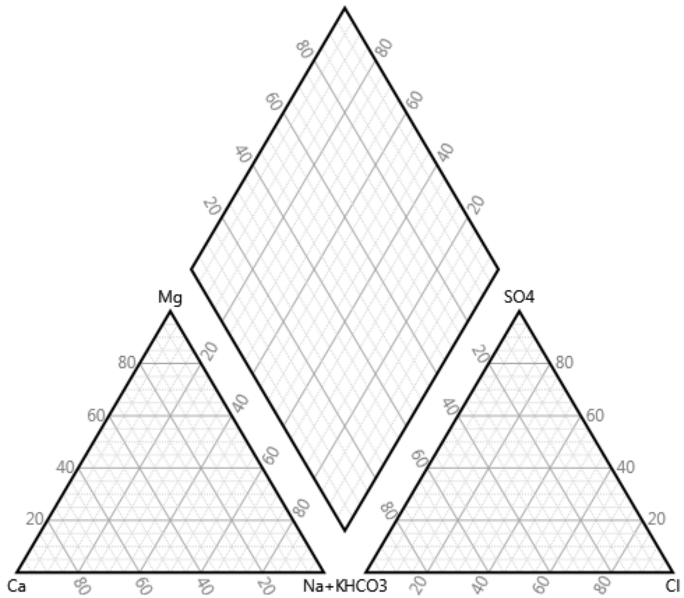
Split sampling data and major water chemistries

Types of plots and diagrams

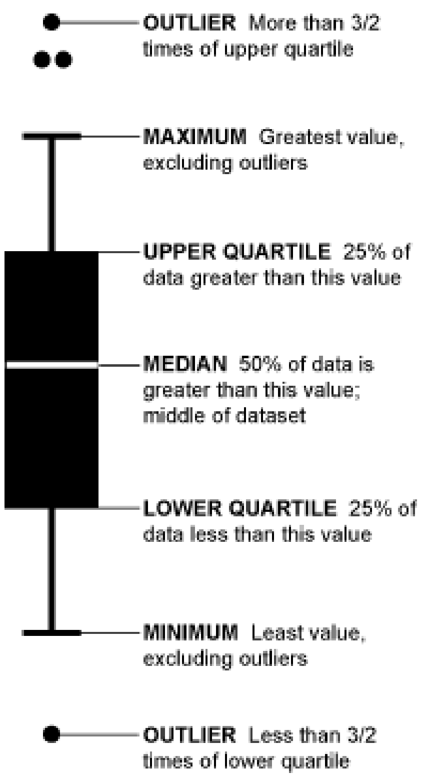
Stiff diagram



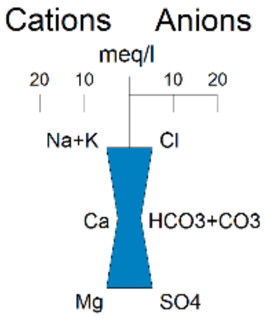
Piper diagram



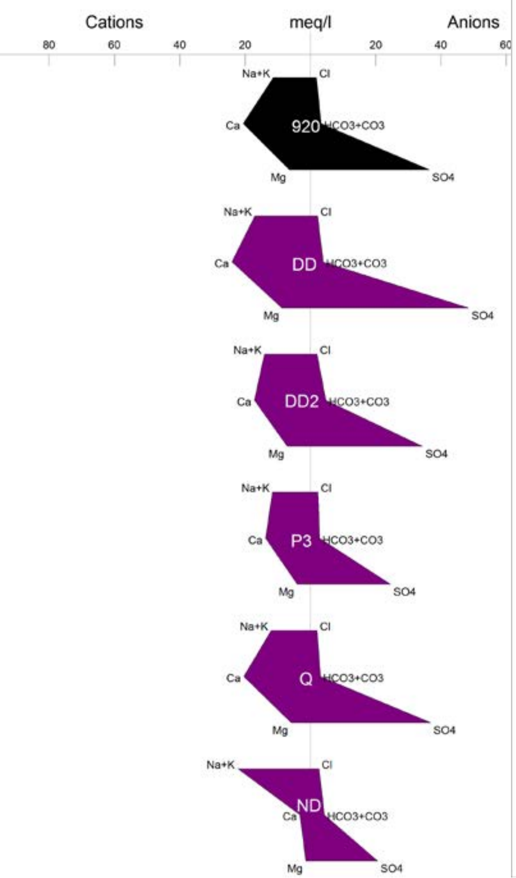
Box plot



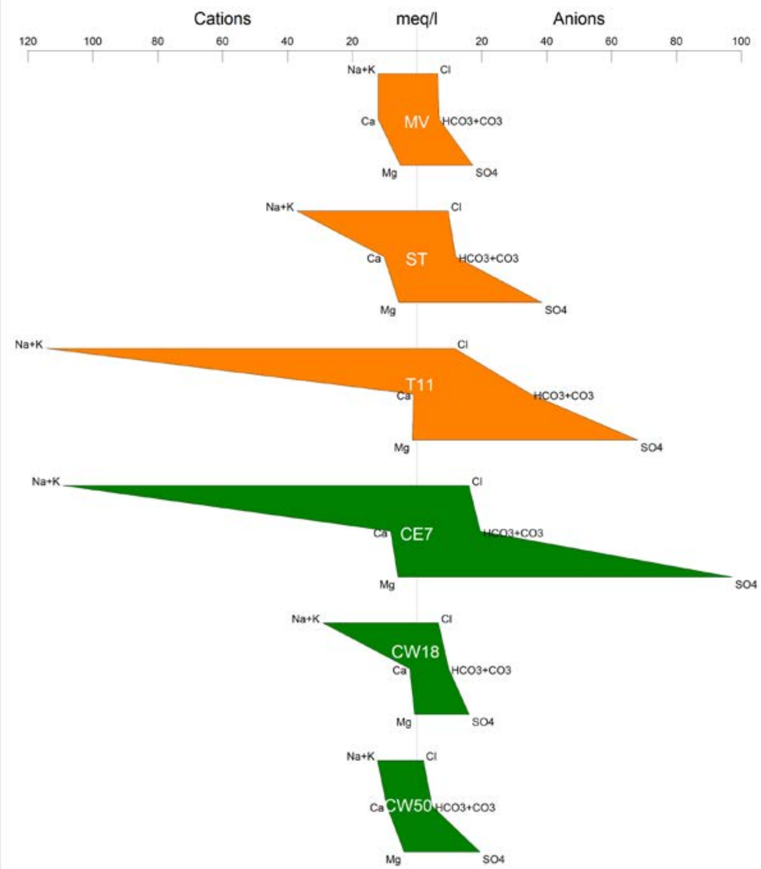
https://flowingdata.com/2008/02/15/how-to-read-and-use-a-box-and-whisker-plot/



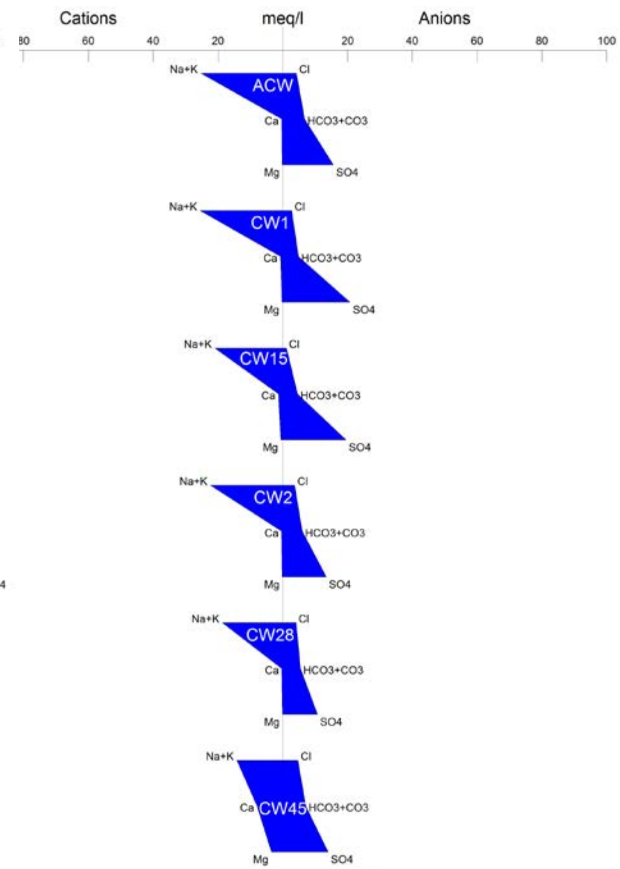
Stiff Diagrams: Upgradient wells

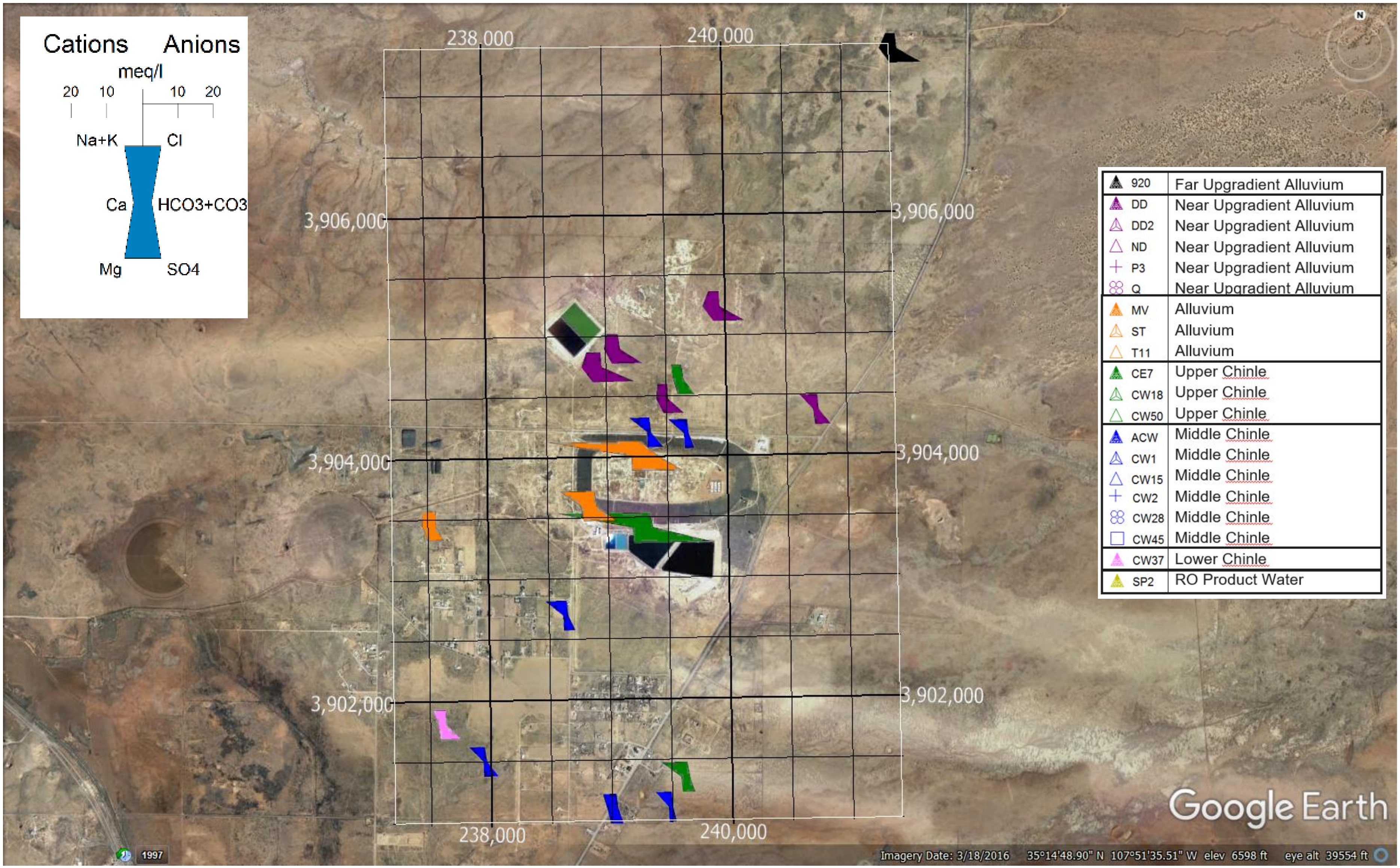


Alluvium (orange) and Upper Chinle (green)

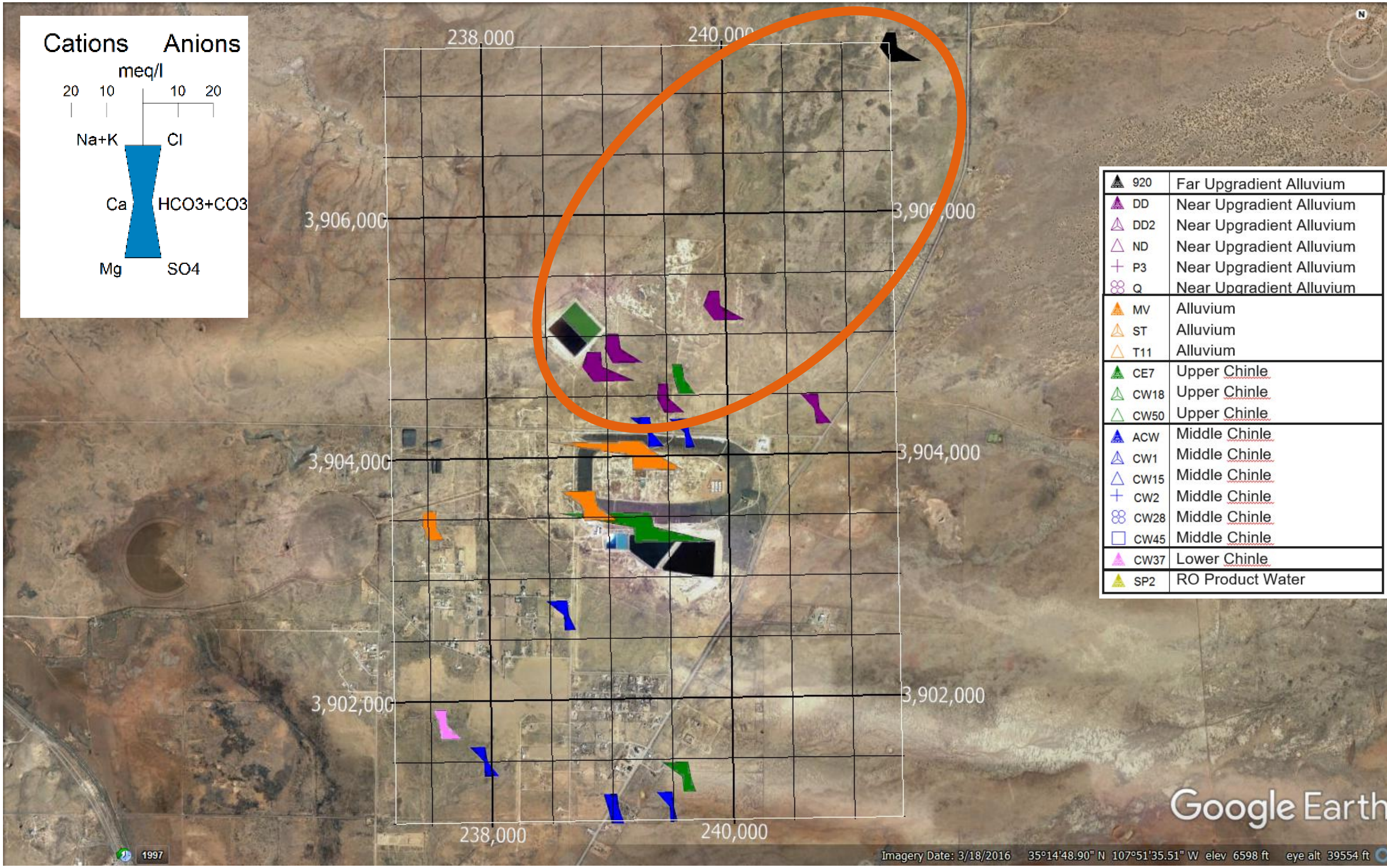


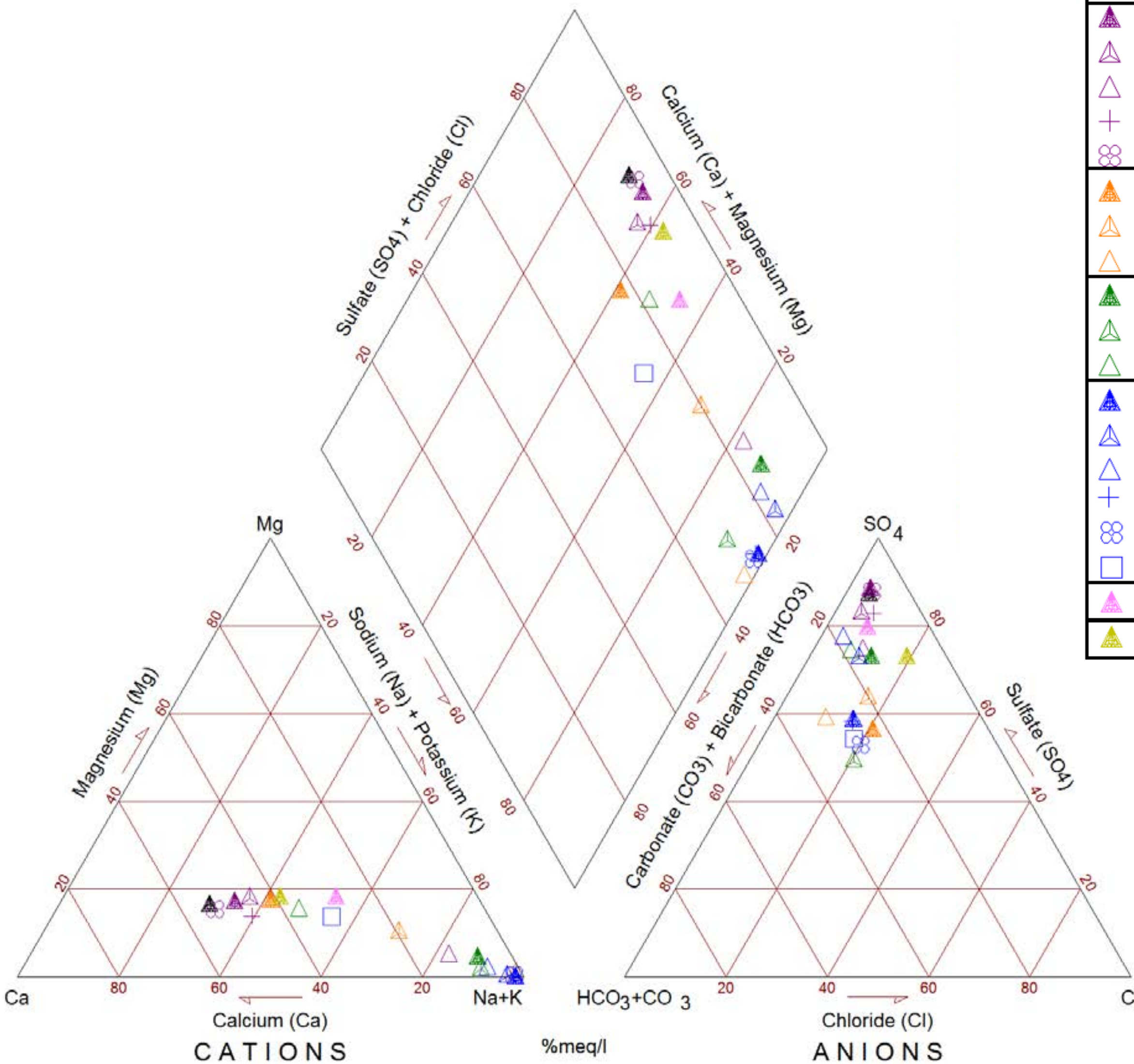
Middle Chinle




Cations Anions
meq/l
20 10 10 20
Na+K Cl
Ca HCO3+CO3
Mg SO4
238,000
240,000
3,906,000
3,904,000
3,902,000
920 Far Upgradient Alluvium
DD Near Upgradient Alluvium
DD2 Near Upgradient Alluvium
ND Near Upgradient Alluvium
P3 Near Upgradient Alluvium
Q Near Upgradient Alluvium
MV Alluvium
ST Alluvium
T11 Alluvium
CE7 Upper Chinle
CW18 Upper Chinle
CW50 Upper Chinle
ACW Middle Chinle
CW1 Middle Chinle
CW15 Middle Chinle
CW2 Middle Chinle
CW28 Middle Chinle
CW45 Middle Chinle
CW37 Lower Chinle
SP2 RO Product Water
Google Earth
1997
Imagery Date: 3/18/2016 35°14'48.90" N 107°51'35.51" W elev 6598 ft eye alt 39554 ft

ARCADIS Design & Consultancy for natural and built assets



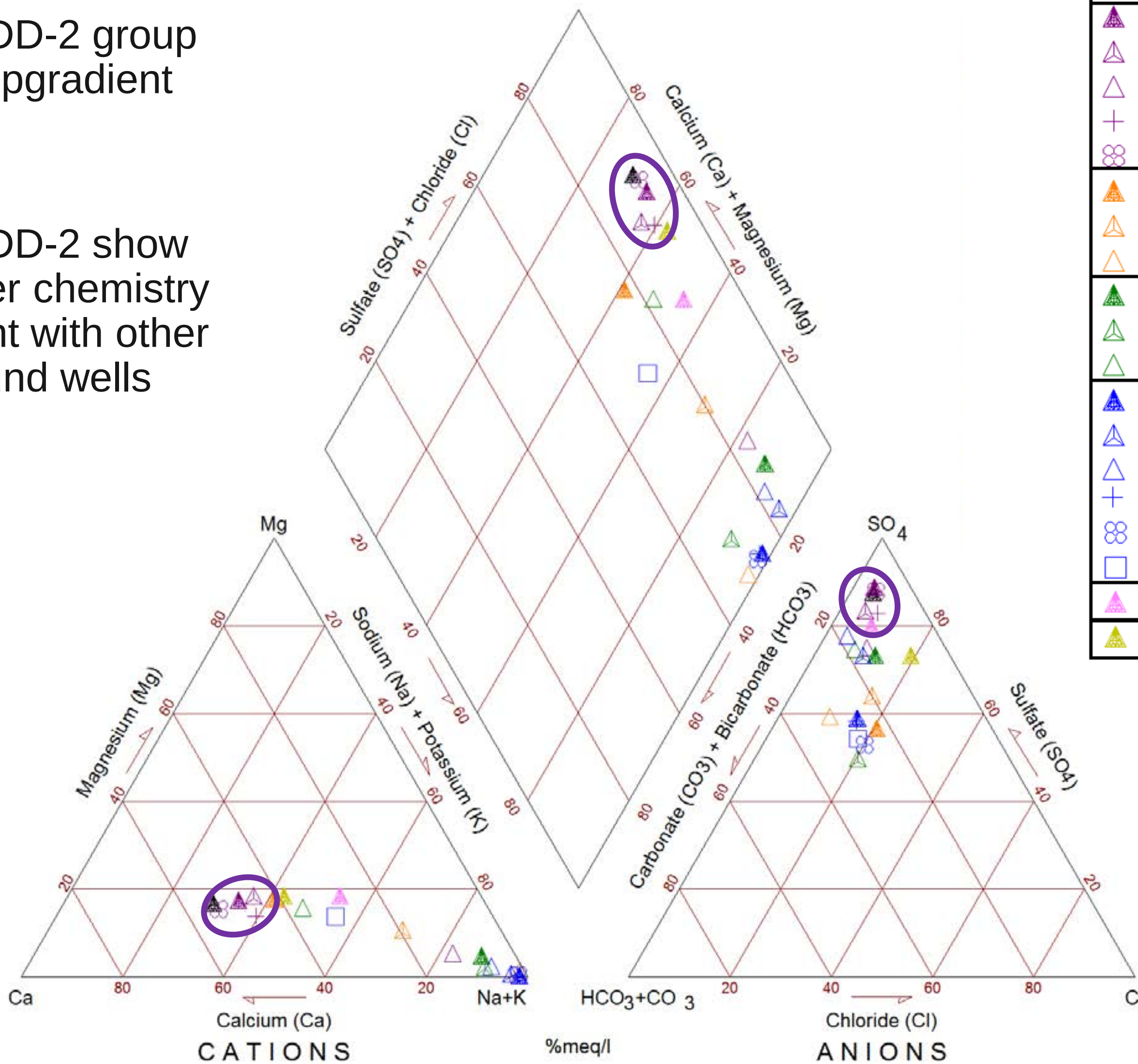


920	Far Upgradient Alluvium
DD	Near Upgradient Alluvium
DD2	Near Upgradient Alluvium
ND	Near Upgradient Alluvium
P3	Near Upgradient Alluvium
Q	Near Upgradient Alluvium
MV	Alluvium
ST	Alluvium
T11	Alluvium
CE7	Upper Chinle
CW18	Upper Chinle
CW50	Upper Chinle
ACW	Middle Chinle
CW1	Middle Chinle
CW15	Middle Chinle
CW2	Middle Chinle
CW28	Middle Chinle
CW45	Middle Chinle
CW37	Lower Chinle
SP2	RO Product Water

Piper Diagram: the standard for fingerprinting water

DD and DD-2 group with far upgradient well 920

DD and DD-2 show bulk water chemistry consistent with other background wells



	920	Far Upgradient Alluvium
	DD	Near Upgradient Alluvium
	DD2	Near Upgradient Alluvium
	ND	Near Upgradient Alluvium
	P3	Near Upgradient Alluvium
	Q	Near Upgradient Alluvium
	MV	Alluvium
	ST	Alluvium
	T11	Alluvium
	CE7	Upper Chinle
	CW18	Upper Chinle
	CW50	Upper Chinle
	ACW	Middle Chinle
	CW1	Middle Chinle
	CW15	Middle Chinle
	CW2	Middle Chinle
	CW28	Middle Chinle
	CW45	Middle Chinle
	CW37	Lower Chinle
	SP2	RO Product Water

Design & Consultancy for natural and built assets

Split Sampling data – sampling methods

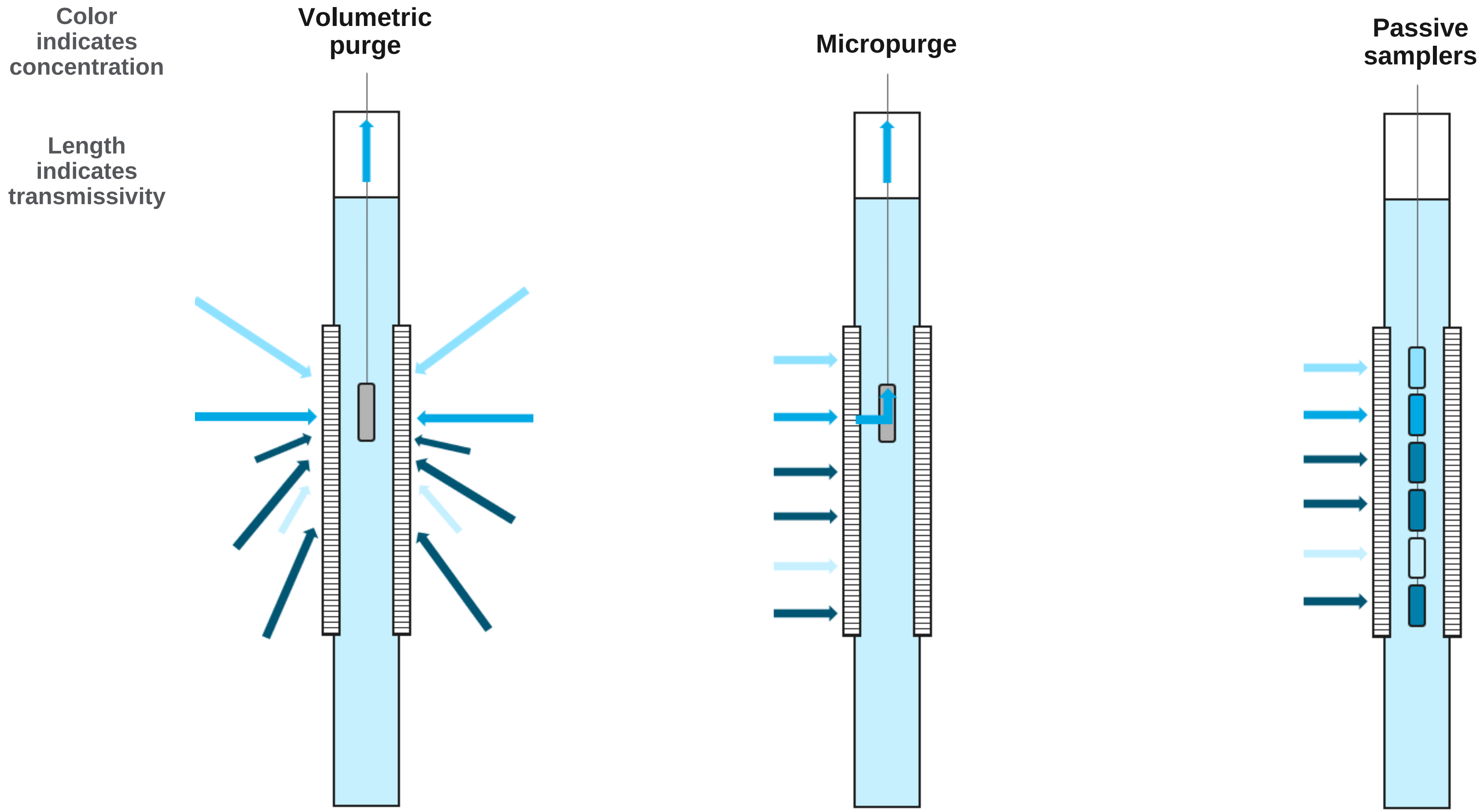
Results by sample method

ARCADIS Design & Consultancy for natural and built assets

- ➢ Volumetric purge
  - 3 casing volumes
  - Parameter stability

- ➢ Micropurge: immediate collection of first water

- ➢ Passive samplers: collection of equilibrated water



Volumetric purge

- Direct sample of aquifer water
- 3D spatial average
- More transmissive zones dominate, but pulls from low transmissivity units
- Clears well of misrepresentative water prior to sampling

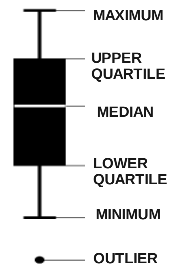
Micropurge

- Direct sample of well water at discrete depth
- If tight formation, sample is solely well water
- <u>Should roughly equal passive sampler data at same depth</u>

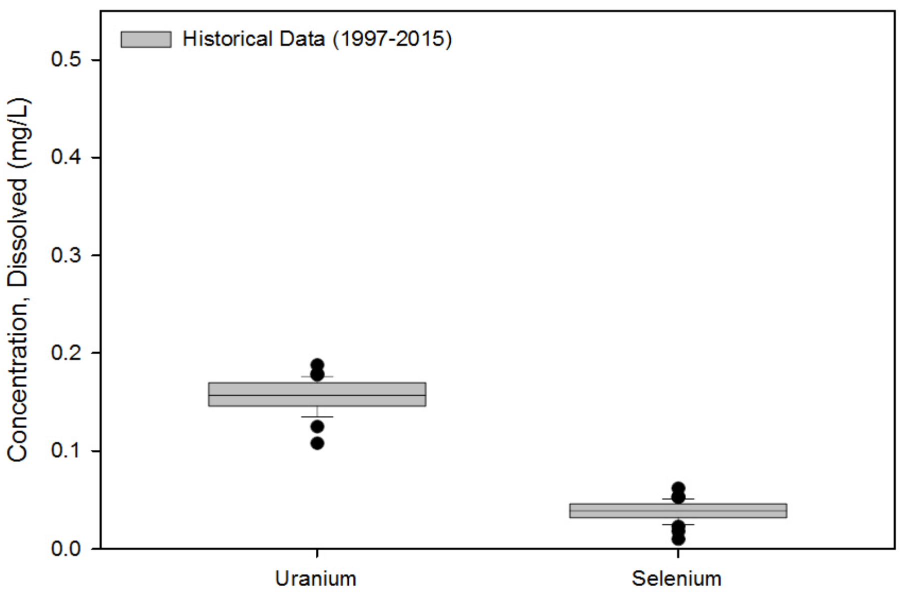
Passive samplers

- Equilibrate with water in well
- Time-weighted average of all water through well over entire deployment (4 weeks)
- Theory: represents water flowing through formation at that discrete depth

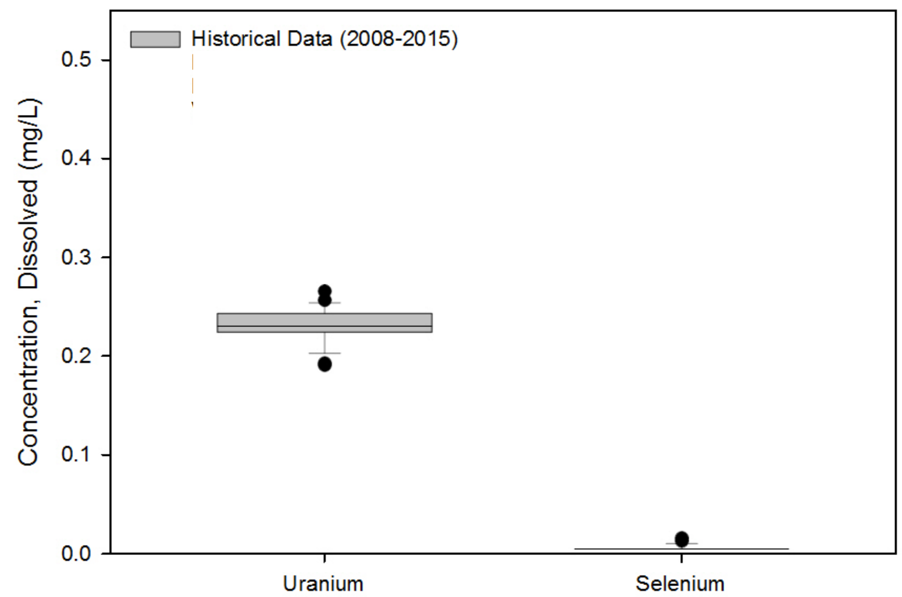
DD and DD-2 split sampling results compared to historical data



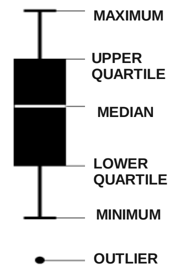
Well DD



Well DD-2

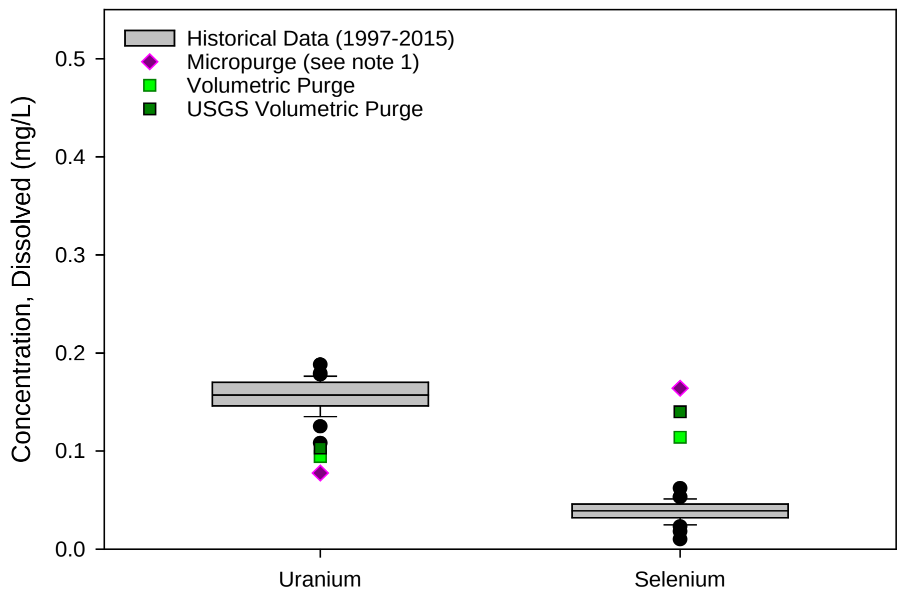


DD and DD-2 split sampling results compared to historical data



DD

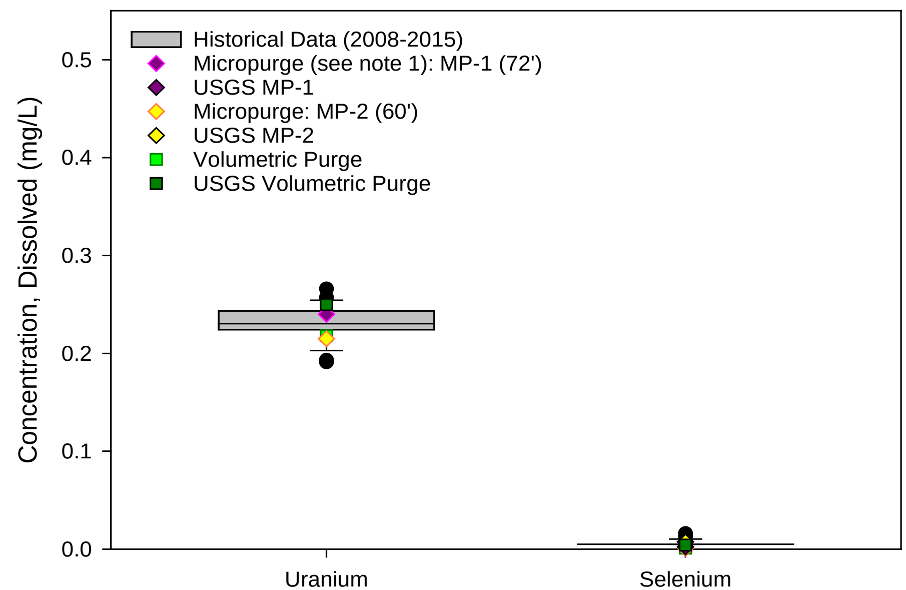
Micropurge and volumetric purge showed lower uranium and higher selenium than is typical of well DD



Notes:
1. Micropurge concentrations are total metals, not dissolved.

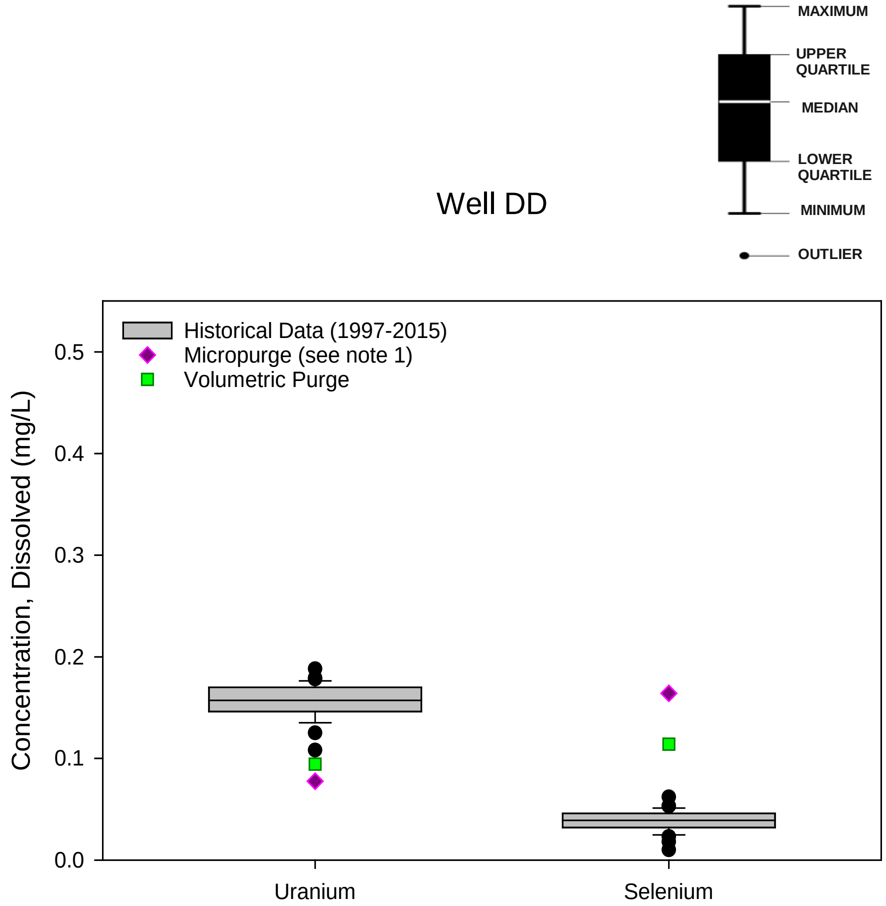
DD-2

Micropurge and volumetric purge showed similar uranium and selenium as is typical of well DD-2



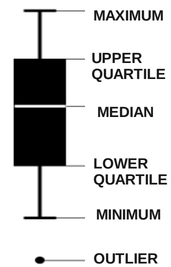
Notes:
1. Micropurge concentrations are total metals, not dissolved.

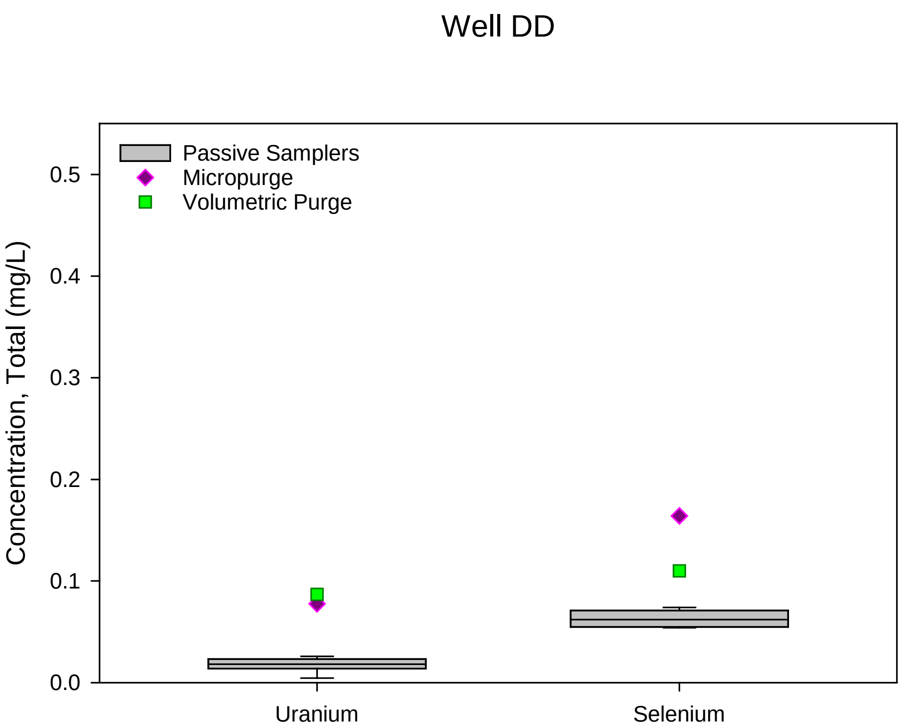
Results by sample method: well DD



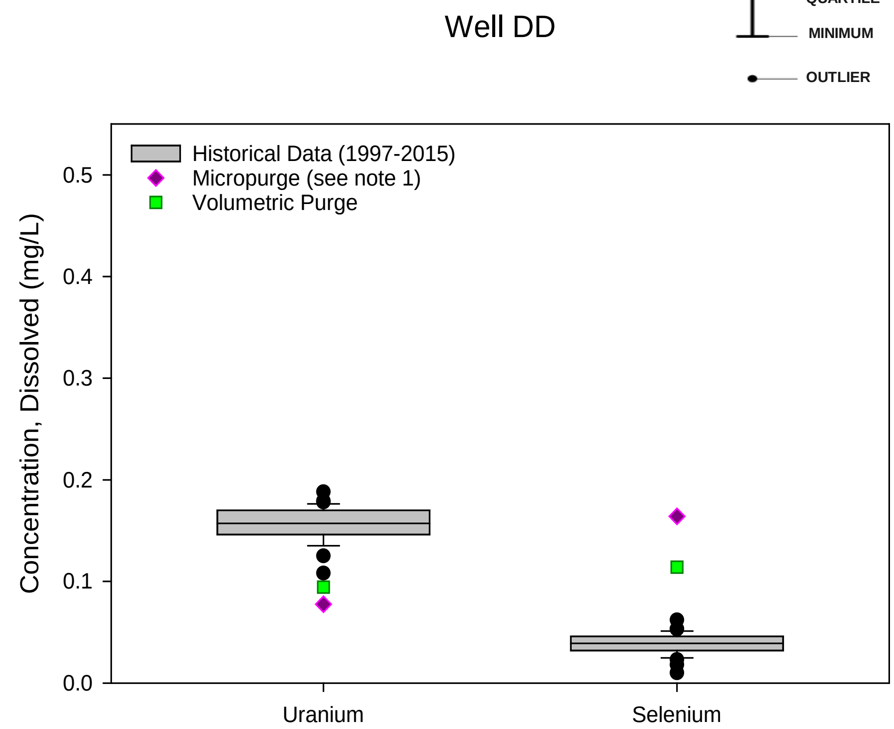
Notes:
1. Micropurge concentrations are total metals, not dissolved.

Results by sample method: well DD





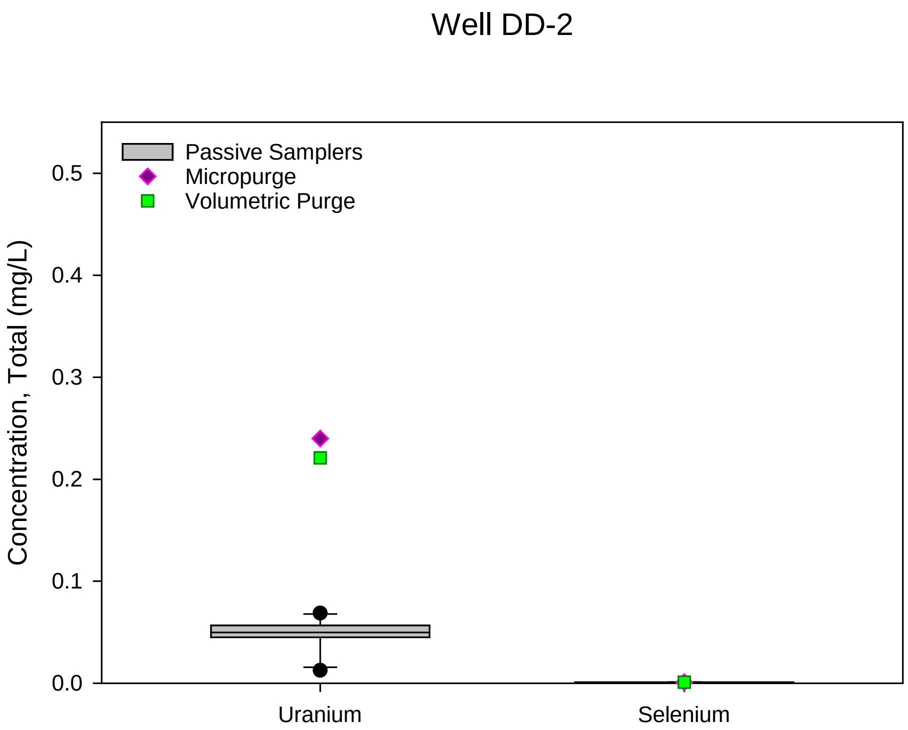
Passive sampler results are much lower than either micropurge or volumetric purge

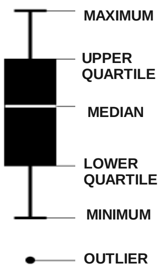


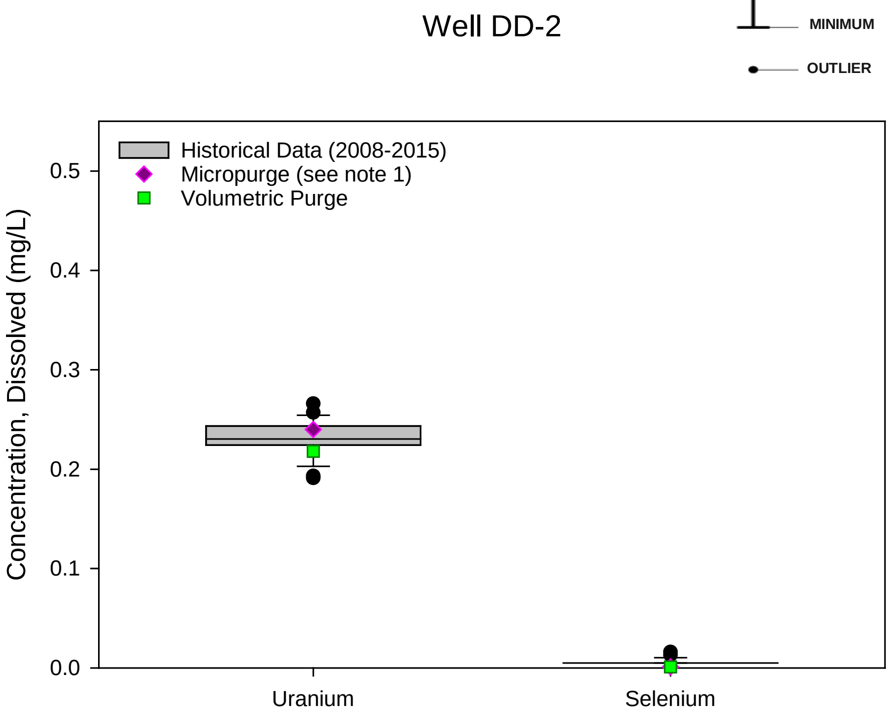
Notes:
1. Micropurge concentrations are total metals, not dissolved.

Passive sampler results are also much lower than historical data

Results by sample method: well DD-2







Notes:
1. Micropurge concentrations are total metals, not dissolved.

Passive sampler results are much lower than either micropurge or volumetric purge

Passive sampler results are also much lower than historical data

Results by sample method

Closed square = volumetric purge

Open circle = micropurge

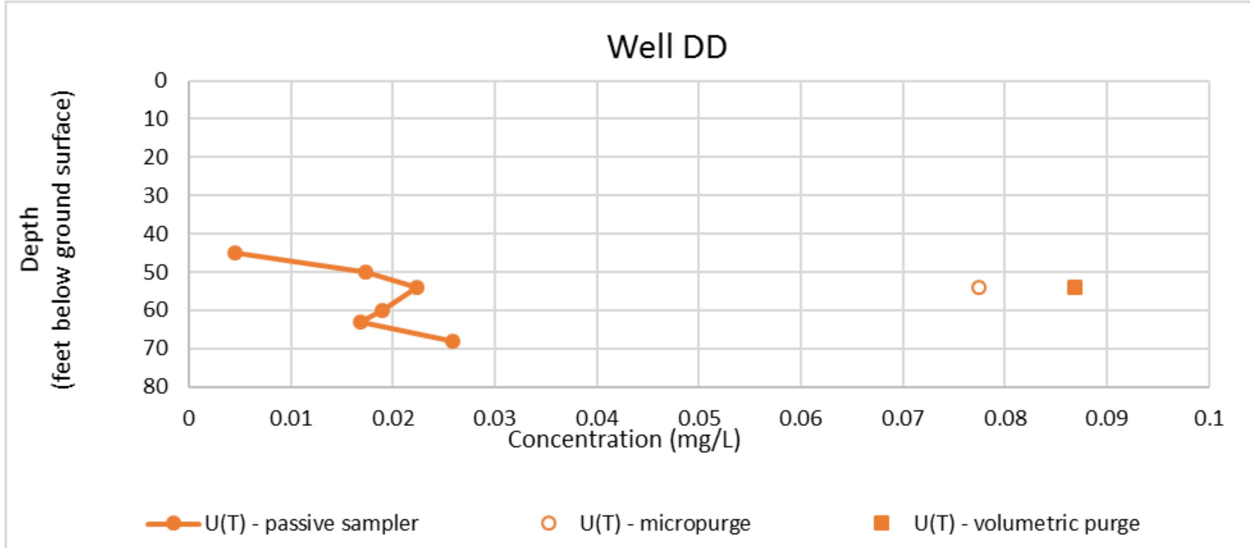
Closed circle, line = passive samplers

Results by sample method

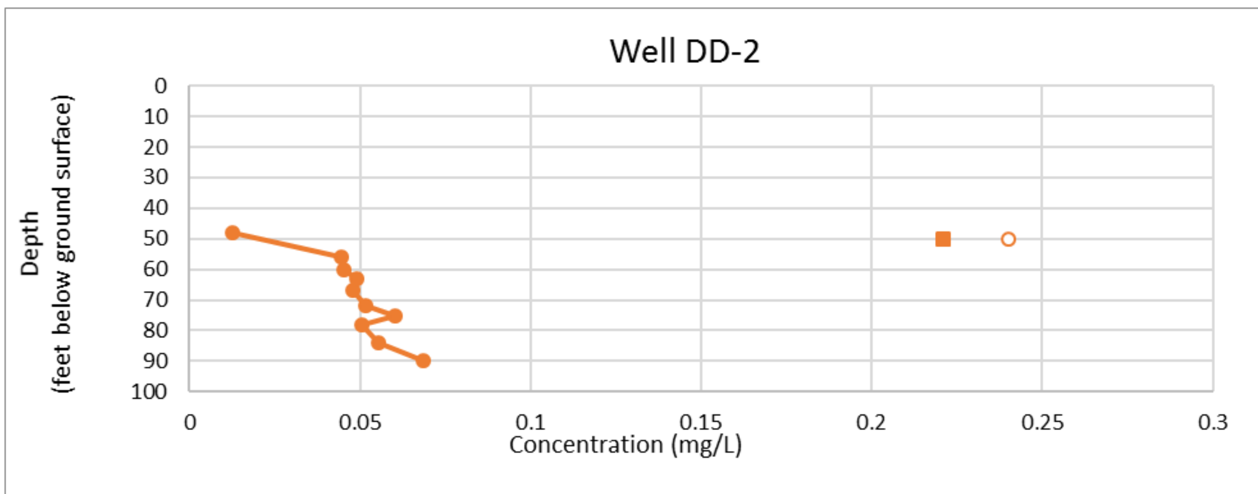
Closed square = volumetric purge

Open circle = micropurge

Closed circle, line = passive samplers



Passive sampler results are much lower than either micropurge or volumetric purge



Passive sampler results are not equivalent to micropurge results at same depth

Results by sample method

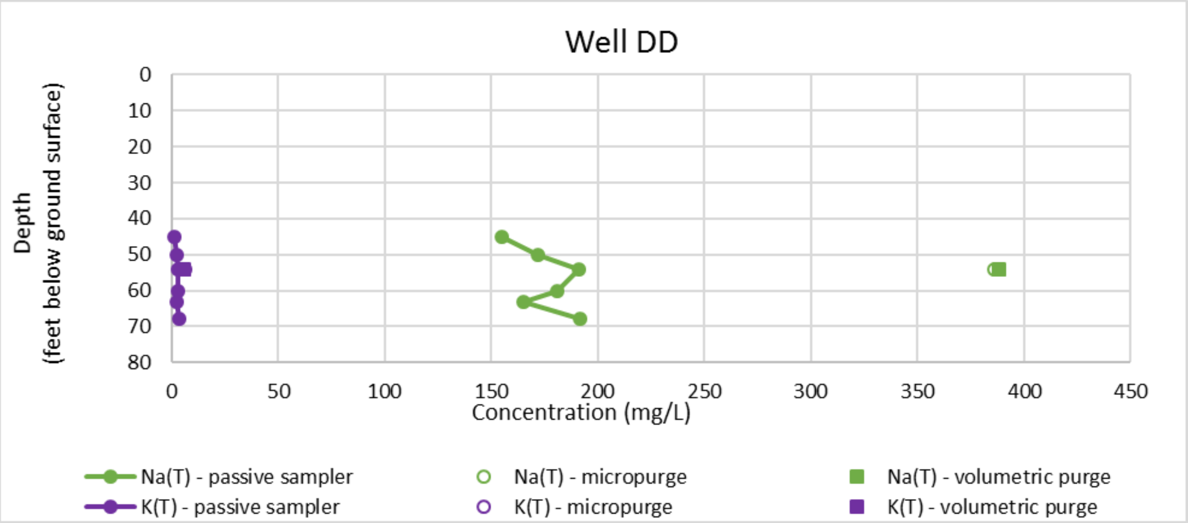
Closed square = volumetric purge

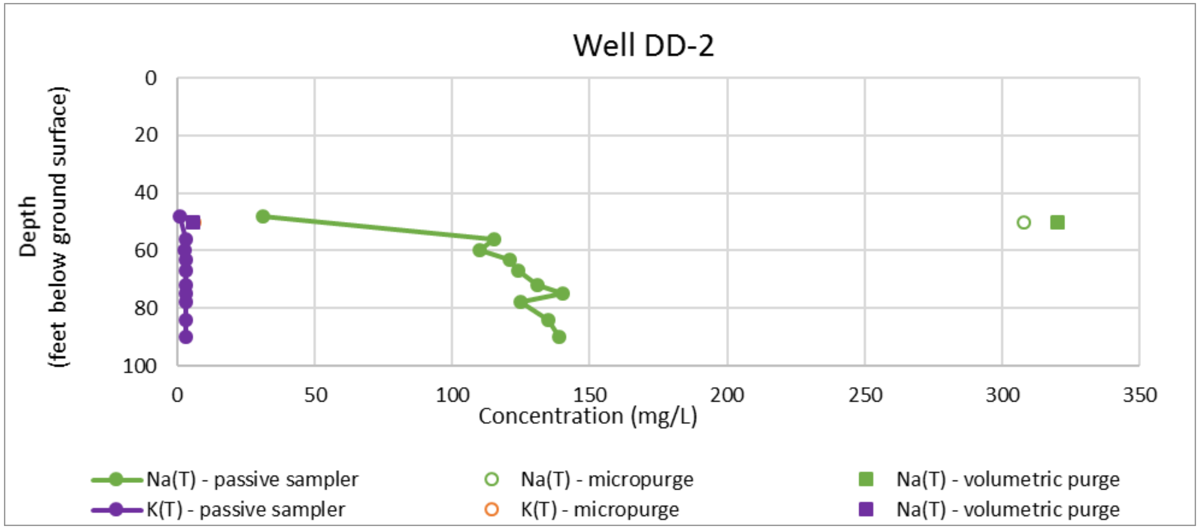
Open circle = micropurge

Closed circle, line = passive samplers

Green is sodium

Purple is potassium





Conservative ions did not equilibrate

Passive samplers did not collect a representative water sample

ARCADIS Design & Consultancy for natural and built assets

Passive Samplers – bench testing

Passive sampler bench testing

- Samplers used in this test were modeled after the samplers used in the split sampling

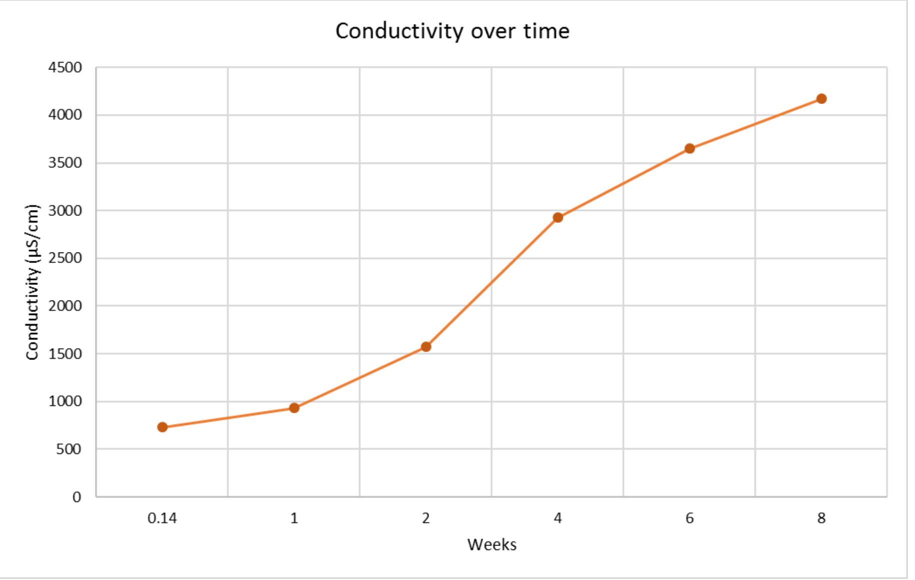
- Opted for setup that allowed as much free flow of water as possible
  - Did not use red netting or any other material that could restrict flow

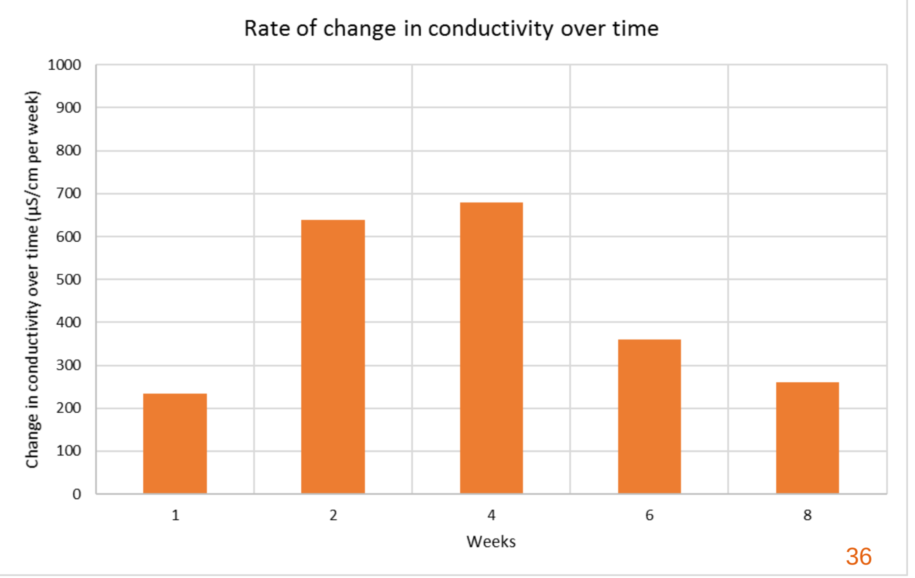
- Tested key elements uranium and selenium

- Tested conservative ions sodium and potassium as controls
  - Should show maximum possible diffusion because these do not react

Passive sampler bench testing results

- Conductivity was still increasing in the collected passive samplers at 8 weeks' time
- Peak change in conductivity in the passive samplers occurred at 4 weeks
- Reflects that highest mass flux was occurring around when passive samplers were collected in the field

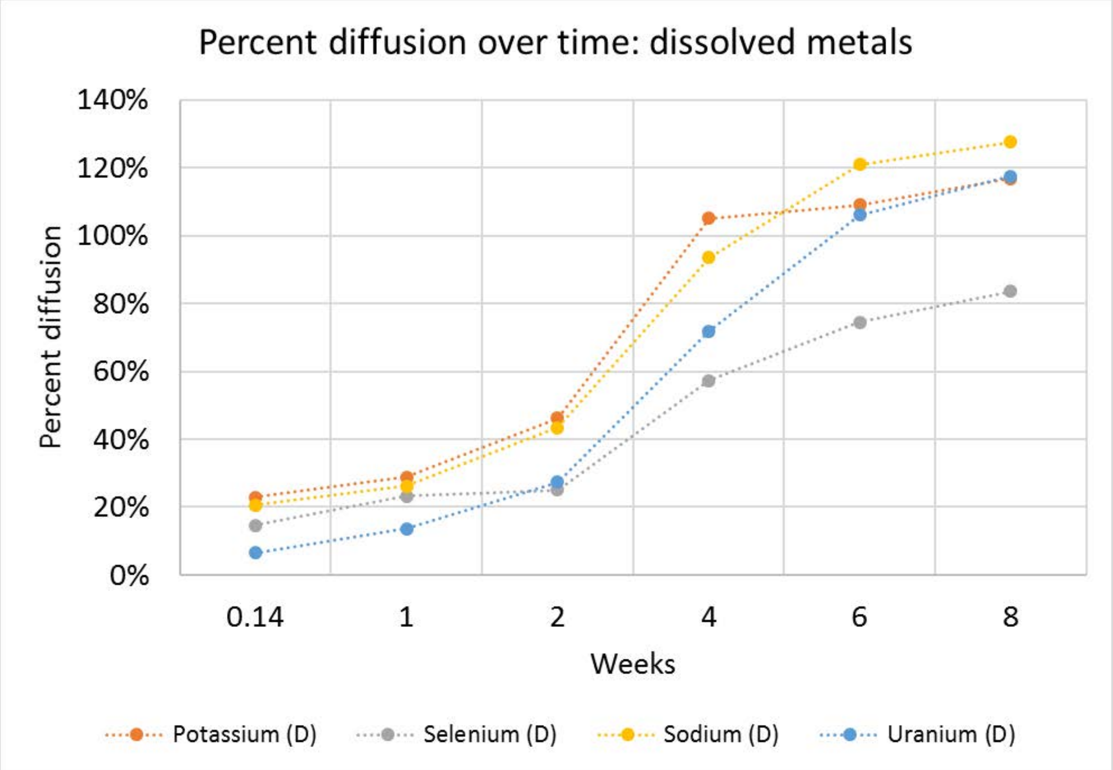




Passive sampler bench testing results

It takes <u>at least 6 weeks</u>, and likely 8+ weeks, for equilibration to occur

We also saw binding to the nylon mesh, including up to 5 mg/kg uranium



	Fully mixed solution	24hr	Week 1	Week 2	Week 4	Week 6	Week 8
Analyte	**% diffusion**	**% diffusion**	**% diffusion**	**% diffusion**	**% diffusion**	**% diffusion**	**% diffusion**
Dissolved Metals by Method SW6010B for Na and K, SW6020 for Se and U (mg/L)							
Potassium	100%	23%	29%	46%	105%	109%	117%
Selenium	100%	15%	23%	25%	57%	75%	84%
Sodium	100%	21%	26%	43%	94%	121%	128%
Uranium	100%	6%	14%	27%	72%	106%	117%

ARCADIS Design & Consultancy for natural and built assets

Geophysics

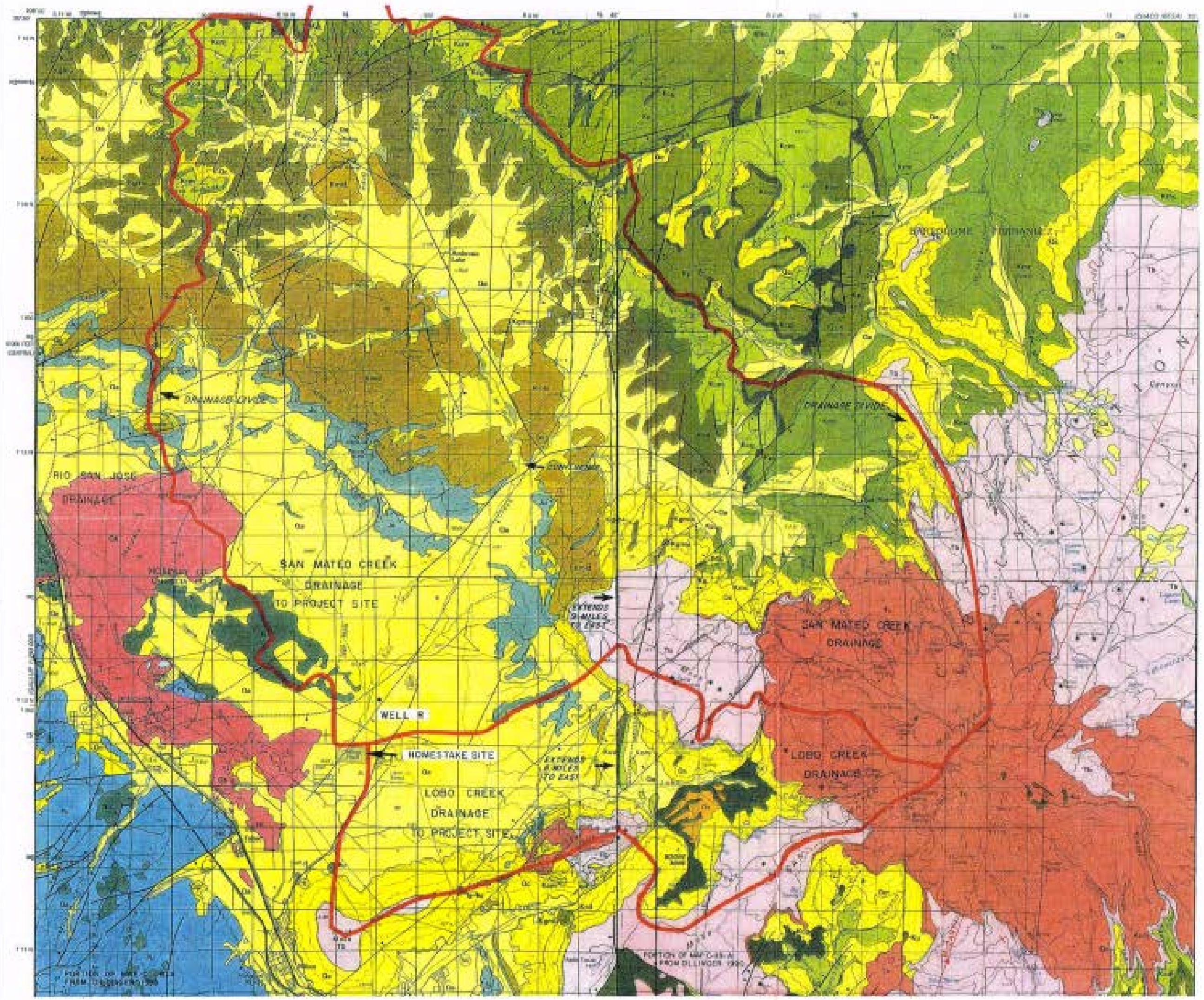
Logging Method Matrix

ARCADIS Design & Consultancy for natural and built assets

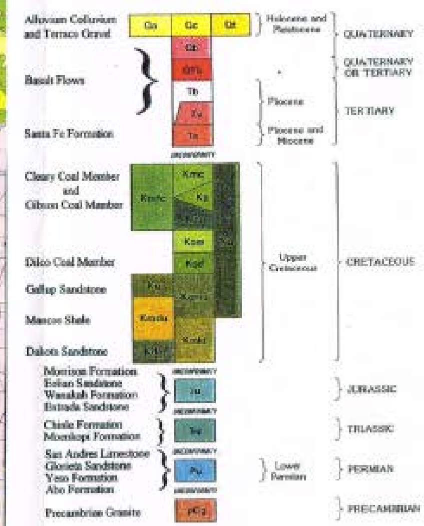
Track	1	2	3	4	5
Content	Natural Gamma Ray Induction Resistivity	Uranium in parts per million (ppm) Thorium/potassium (Th/K) Ratio in ppm/%	Depth in feet	Lithology	Well Construction
Data Used to create Log	Natural Gamma Ray Induction Conductivity	Spectral Gamma Ray data processed into K, U and Th concentrations in picoCuries per gram (pCi/g)	Depth data gathered from each logging run	Natural Gamma, Induction Resistivity, Th/K Ratio, U concentration, Fluid Conductivity, Flowmeter Logs, Descriptive Logs	Optical Televiewer, Caliper, Fluid Temperature, Fluid Conductivity, Well construction documentation
Processing	Minimally processed data provided by USGS	K, U, and Th values recalculated[1] to % or ppm	None	Experience based interpretation	Compilation of historic data and in-well observations from geophysical logging
Comments	Primary logs used to interpret lithology outside the borehole – See Track 4	Uranium plotted as ppm, reflective of presumably U content in matrix primarily. Could provide insight into uranium concentrations in groundwater. Th/K Ratio useful for ascertaining degree of weathering/maturity of sediments, supplemented by Track 4	Common depth reference (ground surface) used for all logging probes, essential for properly aligning various data tracks.	The composite interpretation of geophysical and descriptive log data were used to infer the lithological conditions. Used to create sections A-A' and B-B'	Data mainly provided the condition of the interior of the wells, and historic data used for annular space.

Bedrock Geology Map

ARCADIS Design & Consultancy for natural and built assets



LEGENDS: Correlation of Map Units



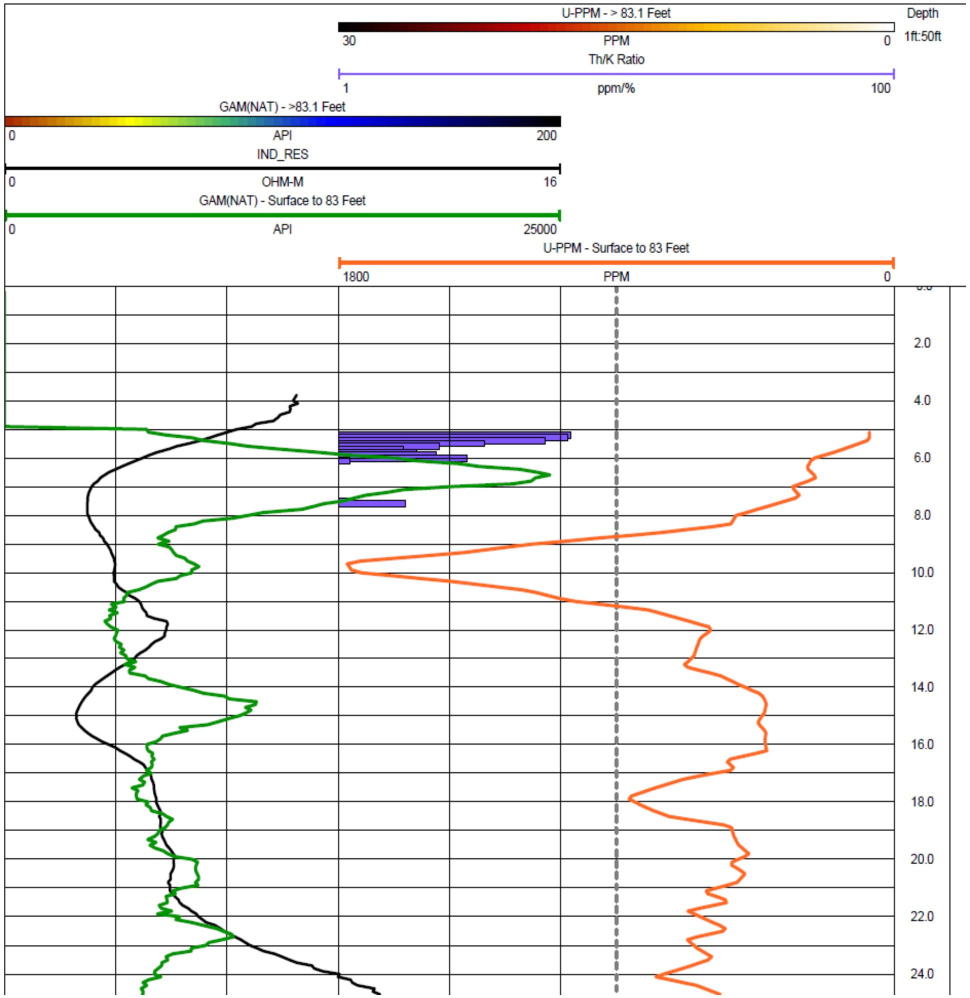
Source:
Dillinger, J.K., 1990, Geologic map of the Grants 30' x 60' quadrangle, west-central New Mexico: U.S. Geological Survey, Coal Investigation Map C-118-A, scale 1:100,000.

GRANTS RECLAMATION PROJECT
Updated Corrective Action Program (CAP)

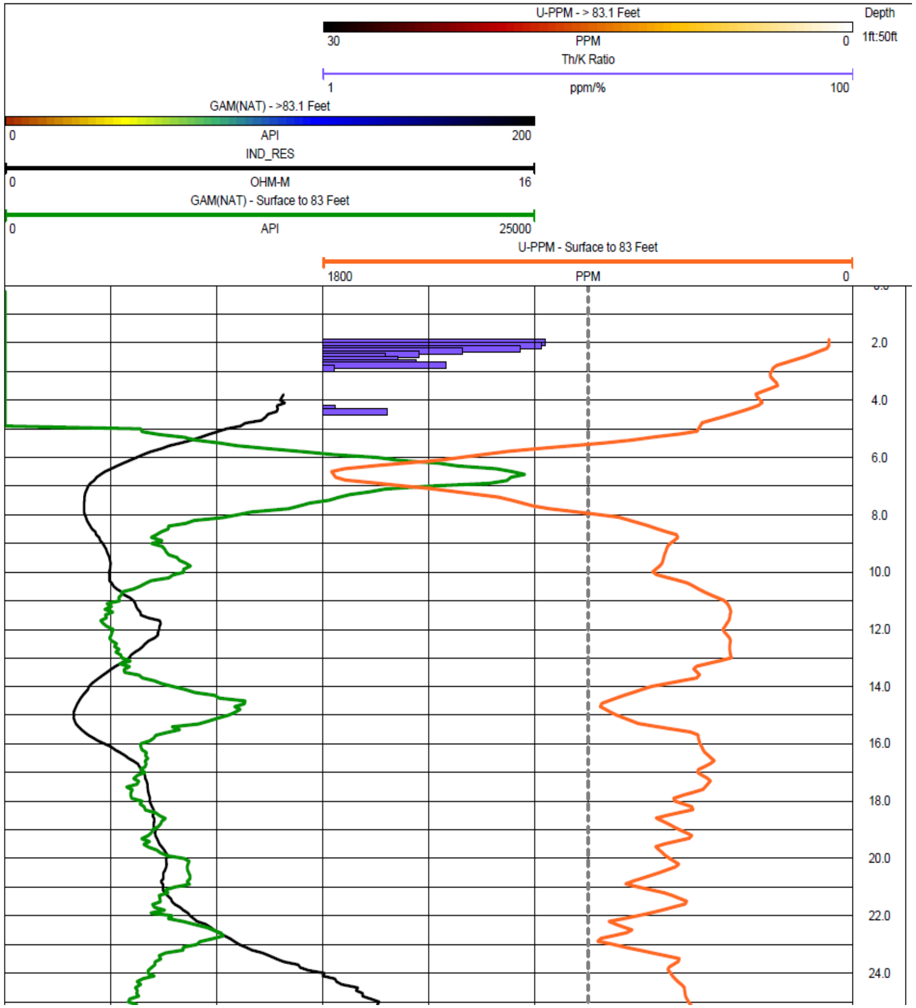
BEDROCK GEOLOGY

Well T11

Uncorrected Spectral Gamma Depth

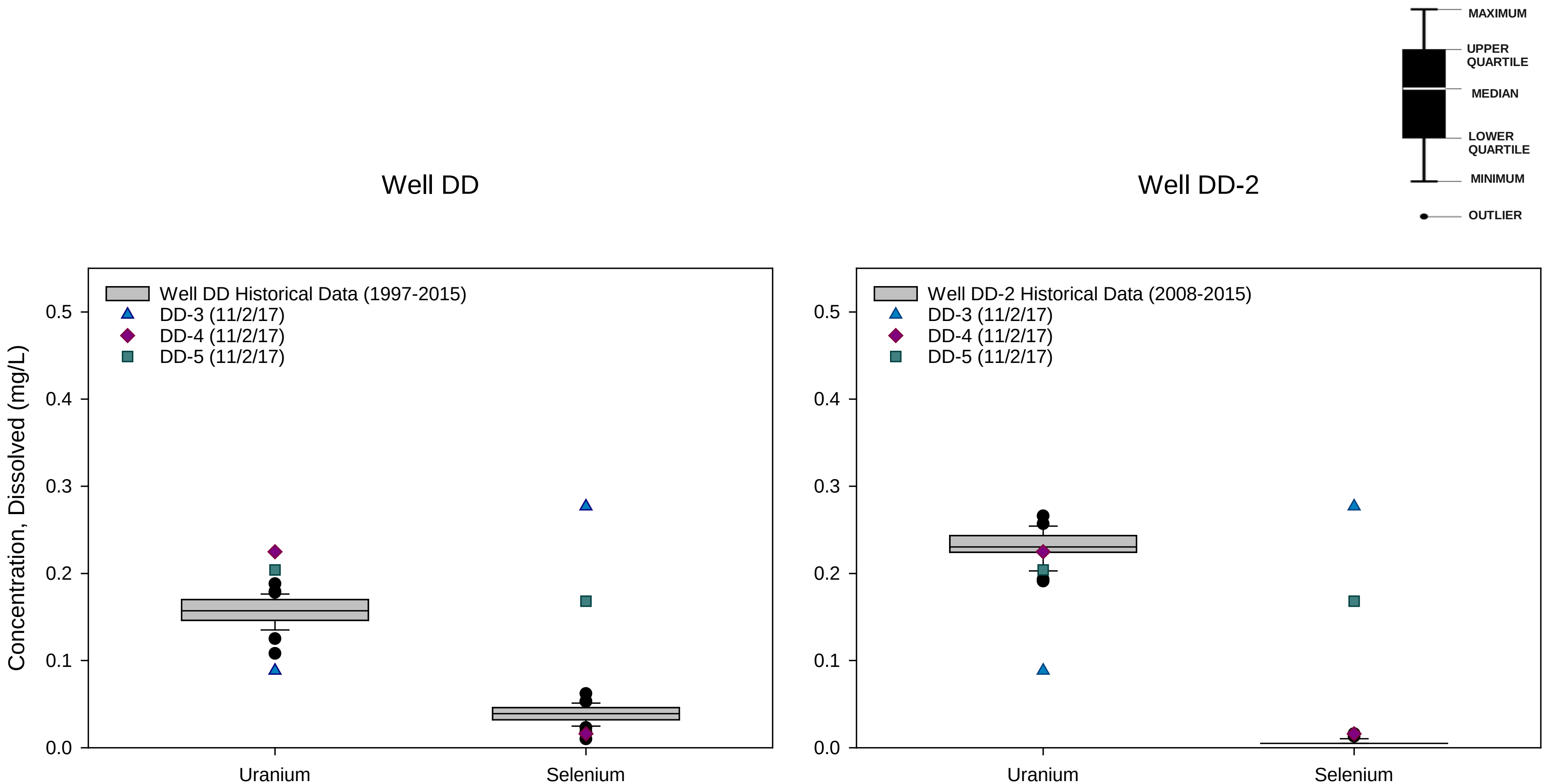


Corrected Spectral Gamma Depth



Wells DD-3, DD-4, and DD-5

Q
DD3
DD4
DD7
DD6
DD2
DD5
DD
CW50
P3
ND
COUNTY ROAD 63
CW1
CW2
T11
LARGE TAILINGS PILE
(RECLAMATION IN PROGRESS)
MO
ST
MV
SP-2
CE7
605
COLLECTION POND
LINED EVAP POND NO. 2
LINED EVAP POND NO. 1
SMALL TAILINGS PILE
PLEASANT VALLEY ESTATES
MURRAY ACRES
ACW
HIGHWAY 605
VALLE VERDE
BROADVIEW ACRES
CW37
FELICE ACRES
RALPH CARD ROAD
THUNDERBIRD LANE
CW15
CW18
CW45
CW28
T12N R10W
T11N R10W
CW26



	U	Se
DD-3	0.0884	0.277
DD-4	0.225	0.016
DD-5	0.204	0.168

DD-6 and DD-7 are dry

Drilling and geophysics at DD and DD-2

Location of boreholes

Geologic logs

- **Previous logging by driller, not geologist, with a mud-rotary rig**
  - **Poor sample quality, very little sample visibility, low-resolution core-logging**
- **This event = high resolution logging, sonic rig**
- **Revised entire cross section for this area**
- **Alternating sands/silts/clays over shale**
- **Consistent with fluvial deposition of eroded grains from nearby source**
- **Sub-angular to sub-rounded grains: sediments transported, but not very far**

Sampling and analysis

Samples collected covering both saturated and unsaturated zones

Sample location selection based on lithological characteristics and on dynamic spectral gamma data

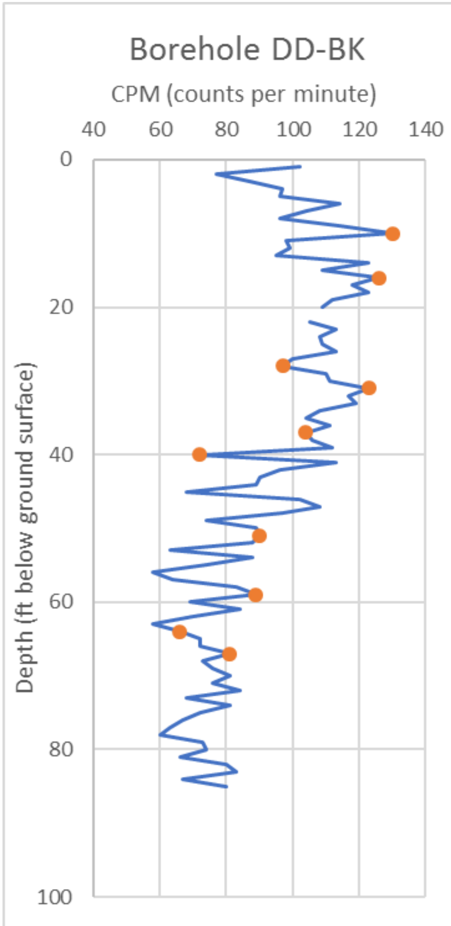
Static spectral gamma collected at each sampling location

Analyses

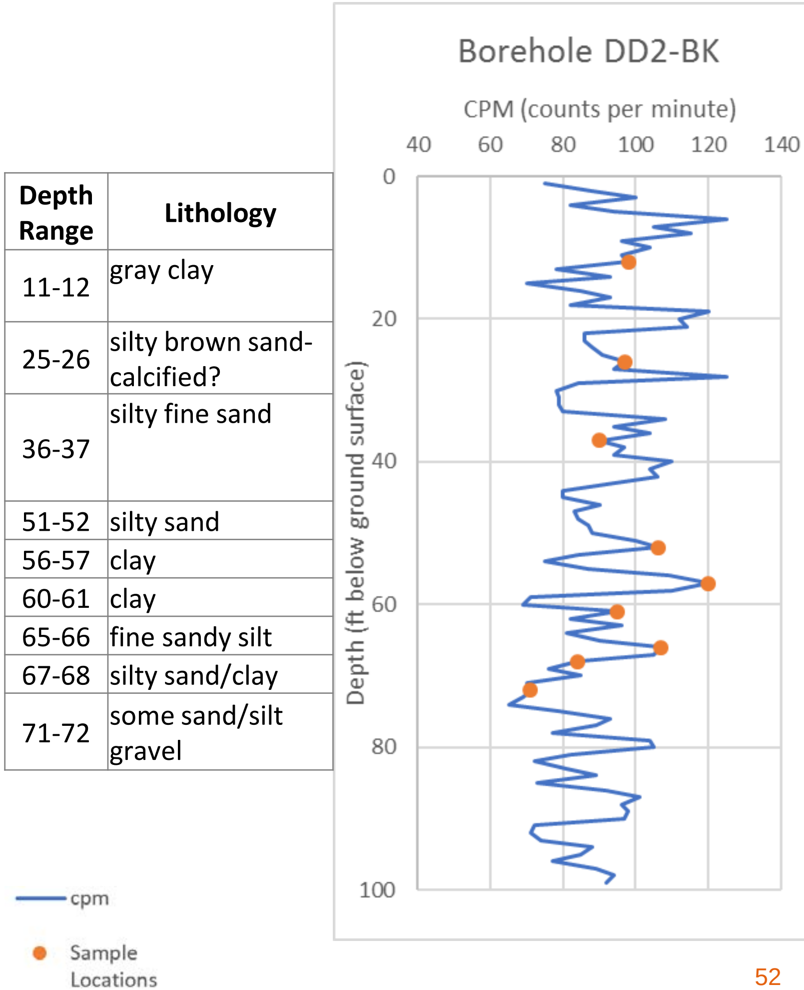
- Total metals
- Alkaline leaching test (modified SPLP based on Kohler et al. 2004)
- Particle size analysis
- Microscopic and spectroscopic analysis

Geologic logs

Depth Range	Lithology
9-10	clay w/ trace sand
15-16	fine to medium sand with some silt
27-28	fine to coarse sand, trace silt
30-31	silty sand and gravel
36-37	clay
39-40	silt fine sand with hard layer
50-51	silty fine to coarse sand
58-59	clay
63-64	silty fine sand
66-67	silty fine sand

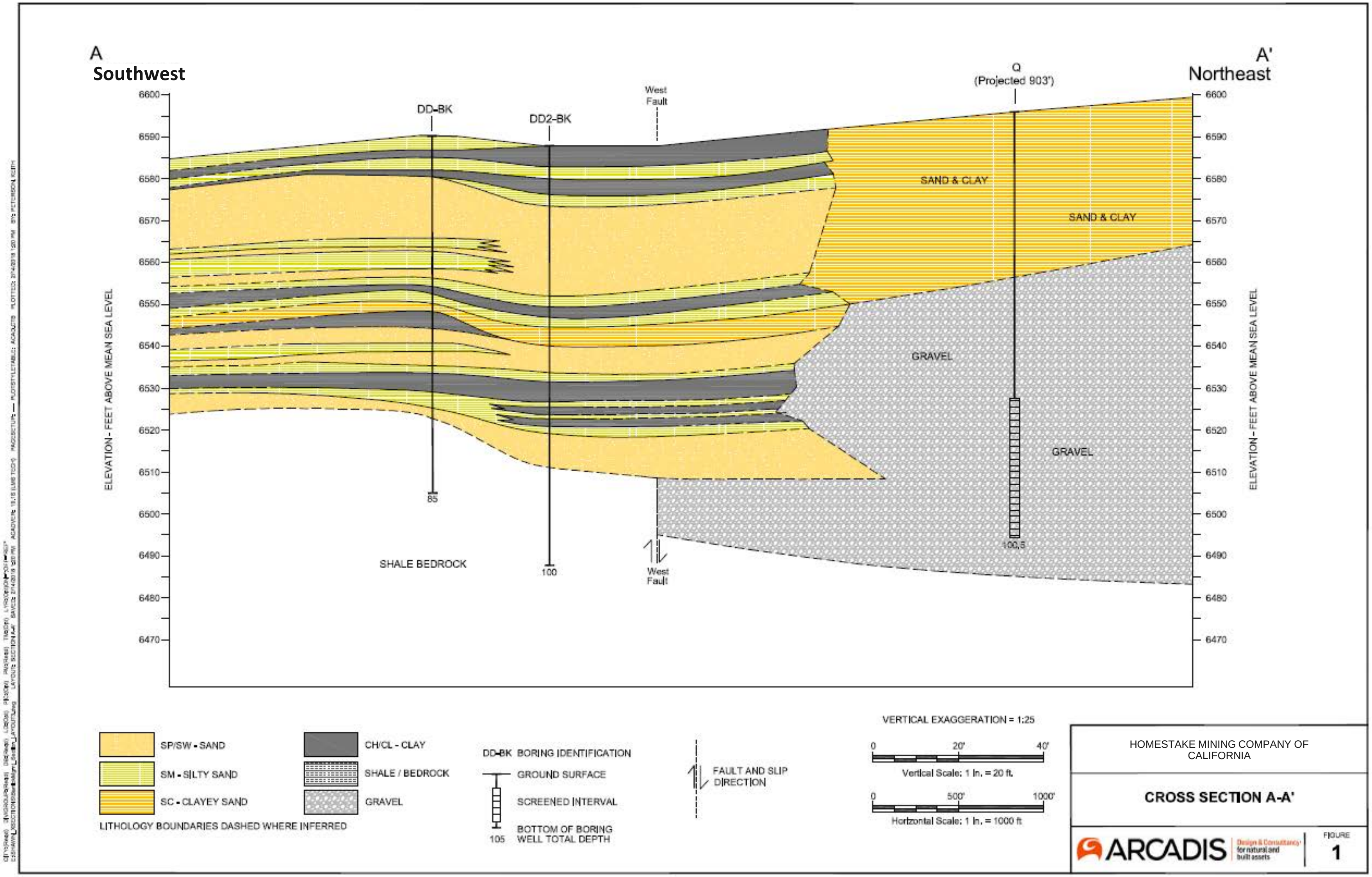


Depth Range	Lithology
11-12	gray clay
25-26	silty brown sand-calcified?
36-37	silty fine sand
51-52	silty sand
56-57	clay
60-61	clay
65-66	fine sandy silt
67-68	silty sand/clay
71-72	some sand/silt gravel



Cross section

New information in this area! Changes the overall interpretation of the DD/DD-2 area and is more consistent with depositional environment as presented by many geologists over last 100+ years



Lab results and report

- Lab results are expected this week for the total metals, leachable metals, and particle size analysis
- Samples will then be selected for microscopy and spectroscopy based on geochemical results
- If data are received in a timely manner, report could be forth-coming by mid-May